PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXI. APRIL, MAY, JUNE, 1893. No. 141.

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☞ It is requested that the receipt of this number be acknowledged.

☞ In order to secure prompt attention it is requested that all correspondence be addressed simply "To the Secretaries of the American Philosophical Society, 104 S. Fifth St., Philadelphia."

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EXTRACT FROM THE LAWS.

THE HENRY M. PHILLIPS PRIZE ESSAY FUND.

Miss Emily Phillips, of Philadelphia, a sister of Hon. Henry M. Phillips, deceased, presented to the American Philosophical Society, held at Philadelphia for Promoting Useful Knowledge, the sum of five thousand dollars for the establishment and endowment of a Prize Fund, in memory of her deceased brother, who was an honored member of the Society. The Society accepted the gift and agreed to make suitable rules and regulations to carry out the wishes of the donor, and to discharge the duties confided to it. In furtherance whereof, the following rules and regulations were adopted by the Society:

First. The Prize Endowment Fund shall be called the "Henry M. Phillips Prize Essay Fund."

Second. The money constituting the Endowment Fund, *viz.*, five thousand dollars, shall be invested by the Society in such securities as may be recognized by the laws of Pennsylvania, as proper for the investment of trust funds, and the evidences of such investment shall be made in the name of the Society as Trustee of the Henry M. Phillips Prize Essay Fund.

Third. The income arising from such investment shall be appropriated as follows:

(*a*) To making public advertisement of the prize and the sum or amount in United States gold coin, and the terms on which it shall be awarded.

(*b*) To the payment of such prize or prizes as may from time to time be awarded by the Society for the best essay of real merit on

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PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXI. APRIL, MAY, JUNE, 1893. No. 141.

Stated Meeting, April 7, 1893.

Mr. SMYTH in the Chair.

Letters of envoy were received from the Nederlandsche Maatschappij ter Bevordering van Nijverheid, Haarlem, Holland; Società Italiana delle Scienze, Naples; Meteorological Office, London, England; Geological Survey Department of Canada, Ottawa; Academy of Science, Tacoma, Washington; Museo de La Plata, Buenos Ayres.

Letters of acknowledgment were received from the Institut Egyptien, Cairo (138); Società Africana d'Italia, Naples (137); Prof. Gaston Maspero, Paris, France (136); Geological Society of America, Rochester, N. Y. (139); Mr. Andrew S. McCreath, Harrisburg, Pa. (139); Department of State, Washington, D. C. (131–136); "Journal of the U. S. Artillery," Fortress Monroe, Va. (137, 138, 139); Society of Natural History, Cincinnati, Ohio (139); Oberlin College, Oberlin, Ohio (137, 138, Catalogue, Parts i–iv); Lick Observatory, Mount Hamilton, Cal. (133); Mr. Everard F. im Thurn, Georgetown, British Guiana (139).

Accessions to the Library were reported from the Institut Egyptien, Cairo; Nederlandsche Maatschappij ter Bevordering van Nijverheid, Haarlem, Holland; Geographische Gesellschaft, Vienna, Austria; Physiologische Gesellschaft, Deutsche Geologische Gesellschaft, Berlin, Prussia; Prof. H. von Helmholtz, Charlottenburg, Prussia; Naturwissenschaftliche Gesellschaft, St. Gall, Switzerland; R. Istituto Lombardo, Milan,

Italy; Società delle Scienze, Naples, Italy; Rassegna delle Scienze Geologiche in Italia, Institut Internationale de Statistique, Rome; R. Accademie delle Scienze, Turin; R. Istituto Veneto, Venice, Italy; Institut de France, Paris; Harleian Society, London, England; Geological Survey of Canada, Ottawa; New England Historic Genealogical Society, American Statistical Association, Boston, Mass.; Connecticut Historical Society, Hartford; Cornell University, Ithaca, N. Y.; American Museum of Natural History, New York; Board of Directors of City Trusts, Engineers' Club, Messrs. Henry Phillips, Jr., Herbert Welsh, Philadelphia; Department of the Interior, U. S. Fish Commission, Washington, D. C.; Academy of Science, St. Louis, Mo.; Lick Observatory, Mount Hamilton, Cal.; Agricultural Experiment Stations, Morgantown, W. Va., Larami, Wyo.; Las Cruces, N. Mex., Tucson, Ariz.; Museo de La Plata, La Plata, Argentine Republic.

Photographs for the Society's Album were received of Dr. F. A. Genth and Prof. F. A. Genth, Jr., Philadelphia.

The death of Isaac Burk (March 30, 1893, æt. 77) was announced.

The Committee on Dr. Phillips' paper on "Gases" reported it worthy of publication in the Transactions of the Society, and was discharged.

Pending nominations Nos. 1249, 1250, 1253, 1255, 1256 were read.

Dr. Ryder presented for the Proceedings a paper entitled "Energy as a Factor in Organic Evolution."

Dr. Cope presented a paper by Thomas G. Gentry on "The Higher Fungi of Philadelphia and its Neighborhood."

Dr. Cope offered the following resolution:

Resolved, That the American Philosophical Society disapproves of the terms of the bill, No. 163, presented by Mr. J. H. Fow to the Legislature of Pennsylvania, entitled "An act to prohibit public exhibitions of mental or physical deformities in certain public places," as opposed to the interests of education and scientific research, and as injurious to the

interests of the class of persons whose exhibition for compensation is forbidden by its terms.

On motion, the Society adopted the resolution and referred the matter to the President, with power to make such representations to the Legislature as he might choose, if in his discretion he saw fit so to do.

And the Society was adjourned by the Presiding Member.

Stated Meeting, April 21, 1893.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows:

A circular relating to the Hodgkins prizes offered by the Smithsonian Institution.

Letters of acknowledgment were received from Mr. Samuel Davenport, Adelaide, Australia (138); Société de Géographie de Finlande, Helsingfors (137, 138); K. Bibliothek, Berlin, Prussia (Transactions, xvii, 1, 2); Société de Geographie, Société Philologique, Marquis de Nadaillac, Profs. E. Levasseur, G. Maspero, Paris, France (139); Comte Hyacinth de Charencey, St. Maurice-les-Charencey, France (139); Prof. Alexander Agassiz, Cambridge, Mass. (139); Mercantile Library, St. Louis, Mo. (Catalogue, Parts i–iv).

Accessions to the Library were reported from the Congrès Internationaux, d'Anthropologie, Archæologie préhistorique et Zoologie, Moscow, Russia; Société de Géographie de Finlande, Helsingfors; Nederlandsche Maatschappij ter bevordering van Nijverheid, Harlem, Holland; K. P. Meteorologisch Institut, K. P. Akademie der Wissenschaften, Berlin, Prussia; Frau Gerhard vom Rath, Leipzig, Saxony; R. Istituto di Studi Superiori, Firenze, Italy; Accademia di Scienze Morale e

Politiche, Naples, Italy; Bath and West and Southern Counties Society, Bath, England; British Association for the Advancement of Science, London, England; Natural History and Philosophical Society, Belfast, Ireland; Harvard University, Mr. A. McF. Davis, Cambridge, Mass.; American Antiquarian Society, Worcester, Mass.; American Oriental Society, New Haven, Conn.; Historical Society, Buffalo, N. Y.; Mr. Lucien H. Smith, Rochester, N. Y.; Free Public Library, Jersey City, N. J.; College of Physicians, American Pharmaceutical Association, Messrs. Finley Acker, Henry Phillips, Jr., Julius Sachse, Philadelphia, Pa.; Office of Chief of Engineers, Department of State, Treasury Department, Bureau of Education, Washington, D. C.; University of Virginia, Charlottesville; California Academy of Sciences, San Francisco; Agricultural Experiment Stations, Storrs, Conn., and State College, Pa.

The following announcements of deaths were made:

Esquiron de Parieu, Paris, died April 9, 1893, æt. 79.

Thomas H. Dudley, Camden, N. J., died April 15, 1893, æt. 74.

The President was authorized to appoint a suitable person to prepare the usual obituary notice of the late Mr. Dudley. (Mr. William John Potts was subsequently appointed.)

The President announced that Dr. Ruschenberger had been appointed to prepare the obituary notice of the late W. B. Rogers.

Mr. Prime made some remarks on "The Present Revolution taking place in Iron-making in the United States," and was followed by Dr. Morris on the subject.

Dr. Ryder presented a paper "On the Mechanical Genesis of the Fowl's Egg."

Nominations Nos. 1249, 1250, 1253, 1254, 1255, 1256, 1257, 1258 and 1259 were read.

And the Society was adjourned by the President.

The Life Histories of certain Moths of the Families Ceratocampidæ, Hemileucidæ, etc., with Notes on the Armature of the Larvæ.

By Alpheus S. Packard.

(*Read before the American Philosophical Society, March 17, 1893.*)

Family Ceratocampidæ.

Judging by the larvæ alone, this group is well circumscribed. The most generalized forms are Dryocampa and Anisota. In these there is no "caudal horn," and the single median dorsal spine on the ninth abdominal segment in Dryocampa is about one-third as long as that of Anisota, while in Sphingicampa the spine is reduced to a minimum. That the larva of Dryocampa is the simplest of the family is also shown by the fact that the two rudimentary spines on the third thoracic segment are shorter and less forked, and the other abdominal spines are shorter than in the other genera.

The suranal plate has the shortest spines in Sphingicampa and longest in Anisota, being of a length intermediate between these two genera in Dryocampa, in which, however, they are still long.

Sphingicampa may be regarded as a transitional form connecting Dryocampa and Anisota with Eacles and Citheronia.

Eacles in its first larval stage, as compared with that of Sphingicampa, differs in the following respects:

The prothoracic segment is armed with spines; the thoracic spines are in Stage I forked at the end; the caudal horn is much longer and slenderer, and also forked at the end; also there is a single median spine on the ninth abdominal segment. Eacles is peculiar in the abdominal segments being marked with two black transverse stripes.

Aglia tau, a connecting link between the Ceratocampidæ and Saturniidæ and the type of a new subfamily, Agliinæ. In this European Bombycine moth we have surviving, side by side with the generalized Saturnia, a most interesting form, which is a Ceratocampid in its earlier larval stages, the larva in its last stage and the moth being very near the Saturnians, although it does not spin a cocoon, and should be regarded as a Ceratocampid. We could not have any clearer demonstration of the origin of one family from another by direct genetic descent.

The transformations of this form, originally figured in Duponchel et Guénée's *Iconographie** (Tome ii), has been more fully elaborated by Mr. Poulton.

Having received, through the kindness of Dr. Heylaerts, a young larva of *Aglia tau* in its third stage, I have been able to compare it with *Eacles*

* Guénée states that after attaining its full size: "Elle se retire à la surface de la terre, entre des mousses et des débris de végétaux qu'elle attache avec de la soie, et elle s'y change en une chrysalide grosse, courte, d'un brun foncé saupaudré de grisâtre, et dont l'anus est terminé par une faisceau de pointes recourbées."

imperialis in its third stage, a thing Mr. Poulton could not do for want of specimens. The resemblance between the two genera at this stage is most striking, although the fully fed larvæ are so different, Aglia passing at a single molt (the third and last, this larva only having *four* stages), from one family to another! We know of no parallel case, or at least of one so very striking and conclusive.* Thus the ontogenetic development of this caterpillar epitomizes that of two families, whereas that of most Bombyces is simply usually only an epitome of that of a subdivision of a family, or of a small group of genera.

Aglia tau in its third stage differs from *Eacles imperialis* in its third stage in having a pair of dorsal "horns" on the first and third thoracic segments, where *E. imperialis* has only minute ones on the prothoracic segment, while those on the second thoracic segment are as well developed as those on the third segment; those on the second segment are minute; all the "horns" are forked as in Eacles. The dorsal spines on the abdominal are simple and minute, like those on the second thoracic segment. The shape of the head and of the anal legs is much as in Eacles, but the suranal plate differs strikingly in being produced into a rather large, spinulated spine, a feature not known to exist in any Ceratocampids.

It should be observed in regard to the large size of the prothoracic horns of Agiia, that those of *Citheronia regalis* are quite well developed, being about two-thirds as long as those on the two succeeding segments.

Upon examining the adult of Aglia, I find that its head and antennæ are closely similar to those of *Hyperchiria io*, and the Hemileucidæ in general; the antennæ form a close approach to those of *H. io*, as on careful examination with a good lens a second branch of the pectinations of the male antennæ can be perceived; it forms a long, separate branch, but is in the dead and dry specimens very closely appressed to the anterior main pectination. In the venation of both wings Aglia shows a most unexpected resemblance to that of *Eacles imperialis;* like that and other Ceratocampidæ and the Hemileucidæ, having five subcostal branches, while in the Saturniidæ there are only four, the first one wanting in the latter family.

Thus the moth belongs with the Ceratocampidæ, while the larva after the last molt loses all its spines and becomes very much like a Saturnian, perhaps of the type of Telea, though it is without tubercles or spines, and especially like a smooth form, the larva of *Attacus betes* Walker, figured by Burmeister in his *Atlas of the Lepidoptera of the Argentine Republic.* We therefore suggest that *Aglia tau* should be regarded as the type of a distinct subfamily of Ceratocampidæ, and thus the latter group may be divided into the two subfamilies, Ceratocampinæ and Agliinæ.

*Over twenty years ago, in 1863, when first beginning my studies on the Bombyces, my attention was attracted to the singular changes of *Aglia tau* and I compared the young larva to the full-grown larva of *Citheronia regalis* and pointed out that the latter genus was an "embryonic form and therefore inferior in rank to the Tau moth" (*Amer. Naturalist*, June, 1870, and *Our Common Insects*, 52).

At present both from their larval and their imaginal characters, and in their spinning a cocoon we are disposed to consider the Hemileucidæ as a family closely allied to, though distinct from, the Ceratocampidæ.

On examining the European genus Endromis, we are disposed to think that the family Endromidæ is a natural one. It would, however, be a violation of the principles of classification to include Aglia with it. The two genera, both as regards their larval and their adult characters, are quite distinct. I find that *Endromis versicolora* has the head, palpi and antennæ and the hairy abdomen very closely like those of our *Hemileuca maia*, but the median vein of both wings divides into four branches, and the subcostal vein of the four wings divides into five branches, as in *H. maia* and the other Hemileucidæ. Judging by the colored figures of the larva in European works, the larva of Endromis is smooth, with a small retractile head, oblique bars, and a conical caudal horn. The group Endromidæ is a branch of the Bombycine tree, parallel to but distinct from the Hemileucidæ, and stands above the latter, connecting the group and the Ceratocampidæ and Saturniidæ with the higher families of the Bombyces, in which there are four branches of the median vein, all the families mentioned agreeing with the Notodontidæ in having but three. In its general shape, the small retractile head, the mode of coloration, and the caudal horn, the larva of Endromis appears to be remarkably near the Sphinges. Buckley describes the cocoon as "composed of an open-worked reticulation of coarse black or black-brown silk threads, with round or broad oval interstices, as the fabric is extremely strong, tough and elastic, covered externally with moss and birch leaves firmly adherent" (iii, 65).

It is interesting that in the transformations of *Rhescynthis erythrinæ*, as figured by Burmeister, we have a parallel to the case of *Aglia tau*. The fully grown larva is smooth-bodied and without the four long large thoracic spines, and the caudal horns on the eighth and ninth abdominal segments of the previous stage. The genus appears to belong to the Ceratocampidæ.

Although we are not yet acquainted with the early larval stages of Endromis, we do not see why the Sphingidæ may not have sprung from a form like this as much as from Aglia, as the shape and markings of the full-grown caterpillar are much nearer a typical Sphinx than those of Aglia. Moreover, taxonomically, Aglia is by no means so "closely" allied to the Sphingidæ as Mr. Poulton in his able papers would lead us to infer. In its venation Endromis is much nearer, and the latter is a more generalized or synthetic form than Aglia. From the Ceratocampidæ the families of Saturniidæ and also of Hemileucidæ may have originated, and indeed all the Bombyces, unless we except the Arctians and Lithosidæ, may have evolved before the Sphingidæ appeared. Judging by the characters of the head, the antennæ, thorax, and especially the venation, the Sphingidæ are far removed from the Ceratocampidæ, and their origin from the latter family was at least remote, and there must be some lost, extinct annectant forms which originally connected them.

The Life History of Dryocampa rubicunda (Fabr.).

The unfertilized eggs laid in New York, July 15, were kindly sent me by Mr. James Angus, but they did not hatch.

Egg.—Length, 1.4 mm. Oval, a little flattened; the shell yellow, thin, parchment-like, the surface smooth, polished, under a one-half inch objective showing no traces of pits or polygonal areas. The shell is so thin that unfertilized eggs collapse irregularly.

Larva Stage I and II.—The larva was found at Providence by Mr. Bridgham about June 20. The following description is drawn up from his excellent colored figures. He says it molts in a day after hatching, and after the molt the larva is the same as before, except that the general color of the body is a little darker, so that the following description will provisionally apply to both stages.

Length, 5 mm. The head is rather large, rounded, no wider than the body, and deep black. The body is of the same width throughout to the ninth abdominal segment. The prothoracic segment a little wider than the rest of the body. From the second thoracic segment arises a pair of thick large horn-like tubercles, which are about as long as the thickness of the segment bearing them; they are greenish at the base and black beyond; the end is blunt, not tapering at all, giving rise to a hair on each side of the end. All the tubercles on the other segments are in the form of small, simple acute spines of nearly uniform size, those on the prothoracic segment being of the same size as those behind the succeeding segment. There are three rows of spines on each side of the body, and the dorsal ones are no larger than those of the subdorsal and subspiracular series. On the eighth abdominal segment there are two widely separate dorsal spines, and two shorter ones on the ninth segment. The body is pale yellowish green, with a median dorsal and a subdorsal dark-green stripe, also a distinct lateral ridge low down, from which the infraspiracular spines arise. The next stage was drawn June 25, "after second molt."

Stage II (?).—Length, 7 mm. The head is now smaller in proportion than before, but still black. *The two horns are now shorter than before* in proportion to the body, but otherwise the same; the other spines are slightly stouter. *The six lines are now reddish, as is the lower (infraspiracular) side of the body.*

Five caterpillars were found feeding side by side on the under side of a red maple leaf, August 12, at Brunswick, Me. They do not start when irritated or use their horns.

Stage III (?).—Length, 8-9 mm. Head rounded, scarcely as wide as the body, very dark chestnut to nearly black. Body cylindrical, not so much flattened as in Anisota. On the first thoracic segment, which is slightly narrower than the second, are two rounded black flattened conical tubercles, not piliferous, and two smaller flatter ones behind. Two larger subtriangular subdorsal black tubercles give rise to three minute short hairs. On the second thoracic segment are two long subdorsal black

spines tapering to the end, which is slightly forked and setiferous, and the spines are minutely spinulated; the two horns are about two-thirds as long as the body is broad. They are represented on the third thoracic segment by two minute conical black tubercles, the homologous ones on the abdominal segments being minute and greenish, tipped with black. Those on the sides of each segment are larger, acutely conical and black. On the eighth abdominal segment are four conical black tubercles, two dorsal and two subdorsal, one on each side. On the ninth segment is a single median conical tubercle, not quite so high as those on the eighth segment, but larger at the base. The subdorsal tubercles on this segment are slightly larger than those on the eighth segment. The suranal plate is subcordate, being excavated in front; behind it is subtriangular, with two black tubercles at the end, which are smaller than those on the side in front of the middle; the suranal plate is greenish, like the prothoracic segment, while the body is tinged with yellowish, with eight faint rather broad whitish longitudinal stripes. The spiracles are black. The thoracic legs are black. The anal legs are greenish, with a blackish patch on the outside near the planta.

In this and the next stage it continues to feed on the under side of the leaf.

Stage IV (?).—(After third molt, June 29) Length, 8 mm. The head is still black, but the two horns are now wholly black, as long as the body is thick, *and spinulated. All the other spines are solid and black;* the two dorsal spines on the eighth abdominal segment being two or three times larger than the others. *The body is now somewhat reddish above* as well as beneath, and the longitudinal stripes are reddish. The prothoracic spines are now rudimentary and button-like.

Stage V (?). — (After fourth molt, July 5, Bridgham.) Length, 10 mm. *The head is now gamboge yellow,* smooth and polished. The two horns as before, being rather slender and spinulated throughout. The body is yellowish green, with faint darker green longitudinal stripes. The tubercles are obsolete, except those on the eighth and ninth abdominal segments, which are black and moderately large.

The following notes were made on caterpillars found in Maine and represent the two last stages of the larva.

Stage V (?).—Length, 20 mm. Head cherry red, about two-thirds as wide as the body, smooth and rounded. Prothoracic tubercles arranged as in the previous stage, *but a little larger and more conspicuous;* in one example the anterior and posterior dorsal ones are coalesced. The second thoracic horns are black, not much more than half as long as the body is broad. *Now the white stripes alternate with the dark-green ones, which are quite distinct,* the black tubercles being situated partly on them. *The tubercles on the abdomen are longer and sharper than before,* and on the base in the middle of the suranal plate is a transverse black plate. The black plate on the ends of the abdominal legs are larger and more conspicuous than before.

Note.—Being now somewhat more exposed when feeding, the head has become of a bright cherry red color, and the body more striped; the armature is longer and sharper, except the two most conspicuous horns of the second thoracic segment.

Final Stage.—Length, 35 mm. The head is considerably narrower than the body, of a uniform pale clay ochre yellow. The prothoracic segment is armed with eight black tubercles arranged in a row across the front edge, the lowest one being placed just above the insertion of the legs, and being acute, while the others are more rounded and button-like. The second thoracic segment bears two dorsal slender black horns, one-half as long as the segment itself is wide, slightly tapering from the base to the end, which is rounded and somewhat truncate. The third thoracic segment with four black conical tubercles like those on the first segment.

The eighth abdominal segment is provided with three black tubercles on each side; the lowest one on this and the seventh segment being larger and sharper than the corresponding ones on segments 1–6. The ninth segment is furnished with a median sharp tubercle, apparently of double origin, as it is slightly forked at the tip; it is about two-thirds smaller than the lateral ones.

The suranal plate is triangular, with the surface flat and rough, ending in two black conical spines, with three on each side in front (in one example two are wanting on one side, and the corresponding ones on the other side are white).

The body is pale pea-green, washed with white on the back between the seven dark-green stripes, one dorsal and three on each side, which are wider and diffuse. The thoracic legs are pale flesh, the abdominal ones greenish. Anal legs large, triangular, rough and granulated, with a few black and white conical spines on the edge above the planta. The fleshy lateral ridge is well developed and washed with a reddish flesh tint on the eighth and ninth segments. The spiracles are jet-black and are conspicuous. The body beneath is as deep, if not deeper green in hue than on the upper side.

Life History of Anisota senatoria (Abbot and Smith).

The larvæ hatched August 1 and 2.

Stage I.—Length, 3.5 mm. Head large, round, smooth, wholly black, a little higher than wide; when seen from in front a little wider than the body. Prothoracic segment a little wider than the second thoracic segment, smooth, unarmed, but with a transverse dusky patch extending across it. The second thoracic segment bears a pair of high clavate spines, which are a little longer than the head is wide, and each bearing two terminal bristles of unequal length. The spines are black, being of the same color as the thoracic legs. The body is *wholly greenish yellow*, with long, rather pale, yellowish-brown hairs arising from conical tubercles. The end of the body is a little more yellowish than towards the head.

August 4 the same larvæ had become 5.5 mm. in length. The body was now *green*, with no yellow tints, and the two horns are *black*. The head is scarcely as wide as the body, and the hairs are greener and less conspicuous.

Stage II.—August 10–12. Length, 7–8 mm. *Head, prothoracic segment* above and horns, with the suranal plate and anal legs jet-black. The body is now *dark green with yellowish-green lateral lines and black conical acute warts. A median dorsal dark line; a subdorsal pale yellowish-green line, and below it a lateral wider line of the same hue, separated by a very narrow dark-green line from a broad lateral line which includes the lateral swollen ridge*, and a row of conspicuous black tubercles. Under side of body dark green. The tubercles on the eighth and ninth segments larger than those in front, suranal plate rough, tuberculated, black. Thoracic horns large, long, black, nearly twice as long as the body is wide, and one-third longer than the head is wide. Thoracic legs black; abdominal feet dark green, except the anal pair, which are black.

Stage III.—August 20. Length, 13 mm. The specific characters now appear, so that the larvæ may be easily identified. The head is slightly narrower than the body. Prothoracic plate distinct, black. The thoracic horns are black, one-third longer than the body is thick. The body is dark yellowish green, or rather olive green, *with two narrow yellowish dorsal lines*, and a subdorsal and a lateral yellowish line on each side. The spines are a little longer and sharper than before, otherwise the larva is as in Stage II.

Partial Life History of Anisota virginiensis (Drury) (pellucida A. and S.).

For the larvæ on which the following descriptions are based, I am indebted to Joseph Bridgham, Esq., who sent them from Providence, July 1.

Stage II.—Length, 7 mm. Head large and full, dark umber, wider than the middle of the body. The prothoracic segment is broad, with the front and sides flaring; upper surface dark chestnut. Body chestnut-amber. From the second thoracic segment two very long, sparsely spinulate, black horns arise, which are nearly half as long as the body; they are a little flattened at the tip, ending in two piliferous tubercles. There are on all the other segments six rows of conical acute black tubercles; the eighth segment is armed exactly as the seventh. On the ninth is a single median spine. The tenth segment or suranal plate is paler than the body, and near the edge are six whitish tubercles; and at the end are two long, piliferous tubercles. The spiracles are distinct, being ringed with black. The thoracic and middle abdominal legs are black; the anal legs of the same varnish-colored tint as the suranal plate. The skin of the body is rough, with two lateral ridges, on the upper one of which the spiracles are situated and on the lower a spine. Across each segment behind the

spine is a transverse row of small whitish warts, and other granulations are scattered over the body. The caterpillar is dark, and a somewhat conspicuous object on an oak leaf. It molted about July 14 or 15.

Stage III.—Length, 15 mm. Head light chestnut; slightly narrower than the body, which is much as before in color and appearance. The two horns on the second thoracic segment are now much shorter in proportion, being one-third longer than the segment is wide, or as long as the second and third thoracic and first abdominal segments taken together. The color of the body is the same, but the white granulations, very unequal in size, are more distinct than before. The spiracles are wholly black, and situated between two indistinct broken white parallel lines. The black dorsal spines on the third thoracic and first abdominal segments are smaller than those on the other abdominal segments; those on the eighth and ninth segments are of the same size and larger than those on the other abdominal segments. The suranal plate and anal legs are of the same color as the rest of the body. It molted July 22, having been about seven days in this stage.

Stage IV.—Length, 21 mm. Head as before, as wide as the body in the middle. Some new marks now appear; there is *a broad, dorsal, dark, longitudinal band* composed of a series of square, dark patches, sprinkled over with thickened white granulations, *and a subdorsal band* of the same color, composed of oblong, dark patches, bearing a spine above, and on the lower edge the black spiracle, situated on a white field. The skin is of the color of beeswax. There is a median black forked spine on the ninth abdominal segment. The suranal plate is as before, but the tubercles are long and slender, rounded at the tip, and porcelain white. The two spines at the end of the suranal plate are tipped with black; this plate and the anal legs being paler than the body. The horns on the second thoracic segment are now shorter than before, or as long as the third thoracic and first abdominal segments taken together. The other spines are as before, those on abdominal segments 4-8 being larger than those on the three segments in front.

For comparative descriptions of the final stage of this and of *A. stigma*, by Dr. C. V. Riley, see our *Forest and Shade Tree Insects*, 125, 127.

Partial Life History of Anisota stigma (Fabr.).

For this larva, received September 12, I am indebted to Mr. James Angus, of West Farms, N. Y.

Stage IV (?).—Length, 25 mm.; length of second thoracic horns, 10 mm. Head Indian red or dull cherry red. *Prothoracic segment with six large stout forked spines*, where those of *A. virginiensis* are small, almost rudimentary, and they are larger than in the final stage. Also the porcelain white granulations are much larger than in *A. virginiensis*. The horns on the second thoracic segment are movable and much longer than in the last stage, being nearly twice as long in proportion. The spines on all the

succeeding segments are of nearly the same size, being nearly one-half as long as the body is thick; those on the third thoracic segment are unevenly forked and of the same size as those of the sixth and eighth abdominal segments; those on segments 1–5 being a little smaller; those on the third thoracic segment are more regularly bifid than the abdominal ones, which have the smaller fork lower down. The single median spine on the ninth segment is no larger than either of the two on the eighth segment, and armed with white spinules. The suranal plate is rounded with six black and several white spines, the basal black ones the largest. The skin is of a peculiar blackish pitchy color. Spiracles black. The thoracic and abdominal legs are dark pitchy; sides of the anal legs reddish, like the suranal plate. *No subdorsal or lateral pinkish stripe, like those in A. virginiensis.*

Last Stage.—Length, 35 mm.; of the second thoracic dorsal spines, 6.5 mm. The head is of the same color as in the previous stage. The second thoracic spine is about as long as the body is thick, and recurved; the other spines are more curved backwards and downwards than in the previous stage, and their shape is very different, the upper surface being smooth, the spinules being collected on the under side; the usually single large spine being white, and beyond the middle, with smaller abortive spinules on the side; these spinules are larger on the spines of the eighth and ninth segments; suranal plate reddish, its surface rough, with white piliferous granulations; near the base is a large black spine on each side, and two black ones of about the same size at the end forming a fork. Spiracles black. Thoracic and abdominal legs pitchy black; sides of the anal legs reddish. Skin dark, with more numerous white granulations than in the previous stage.

It is quite different and easily distinguished from *A. virginiensis;* compared with this species, the head is of the same size but the color quite different, being *dull cherry or Indian red,* while that of *A. virginiensis* is yellowish amber. All the spines are much longer; those on the back of the second thoracic longer, and those behind two or three times longer; *that on the ninth abdominal certainly three times as long as in A. virginiensis.* The skin is blacker, and thus the granulations are more distinct, besides being larger, while *A. stigma lacks the subdorsal and lateral pink or flesh-colored bands present in A. virginiensis.** The spines on the suranal plate are stouter and longer.

Life History of Sphingicampa bicolor (Harris).

Dr. H. S. Jewett has already (*Papilio,* ii, 38 and 144) fully described the egg and the larval and pupal stages of this interesting insect, and I have only to add some details omitted by him. My descriptions were drawn up from living specimens, supplemented by examination of the

* Riley says that the body of *A. pellucida* is two-striped and that the spines are shorter than in *A. stigma.*

alcoholic specimens of the different stages. We have, perhaps, a no more interesting and beautiful caterpillar, whether we consider its peculiar appendages, its rich and gorgeous coloration, or its defensive habits, and the most carefully described details will not be superfluous in comparing the different stages with those of its allies, *Citheronia regalis* and *Eacles imperialis*, and the allied South American forms. I am indebted to my friend, Mr. W. N. Tallant, of Columbus, Ohio, for sending me a good supply of eggs from which the second or July brood of larvæ hatched. The food plant is the honey locust (*Gleditschia triacanthos*), though Dr. Jewett adds *Gymnocladus canadensis*, or Kentucky coffee-tree.

Egg.—Flattened oval, disk-like, each end alike. Length, 1.8 mm.; width, 1.5 mm. At first green in color, as the embryo grows, states Jewett, the egg becomes biconcave and changes to yellowish brown, and from thirty-six to forty-eight hours before hatching the head of the larva shows through as a dark brown spot. The egg is about one-half as large as that of *Eacles imperialis*, but of the same shape. The shell under a lens appears smooth, like parchment; under a one-half inch objective the surface is seen to be ornamented with very faint polygonal impressed areas, which are much fainter and less easy to detect than those of the egg of *E. imperialis*. The swollen nucleus or bubble in each polygon is very indistinct.

It is interesting to compare the sculpturing of the shell with that of *E. imperialis* and *Citheronia regalis*, the former being intermediate between Sphingicampa and Citheronia. In *E. imperialis* the shell is sculptured a little more distinctly with irregular polygonal imprints which are not so closely crowded as in Citheronia, and the median raised nucleus or bubble is pale but tolerably distinct. Length, 3 mm.; width, 2.5 mm. In the shell of the egg of *C. regalis* the polygonal impressed cells are easily recognized under the microscope and faintly detected under a strong lens. The cell imprints are much more distinct and more crowded than in the two other genera, while the median nucleus or bubble is more prominent and darker; it varies in diameter in different cells, being from about a third to a half as wide as the cell itself. The walls are quite irregular and not always distinct.

Larva Stage I.—(Described four to five hours after hatching.) Length, 4 mm. The head is large, rounded, smooth, unarmed, except with a few scattered tapering dark hairs; it is blackish chestnut; it is wider than the body and slightly wider than the prothoracic segment, which is broad and flaring in front, as in Anisota. It is rather higher than wide, and on the vertex slightly bilobed and is paler in front than behind. The terminal joint of the antenna is slightly bulbous and bears besides the tactile bristle about three olfactory rods.

The body is subcylindrical, a little flattened, but not so much so as in Anisota. The prothoracic segment is broad and flattened, smooth and unarmed, except with about a dozen dark small hairs. On each side of the second and third thoracic segments is a subdorsal pair of remarka-

ble movable spines, nearly two-thirds as long as the body, which open and close together like great arms, spreading apart, or directed forwards and outwards more or less constantly while walking, the creature at this age being rather active; they are evidently at this period defensive organs. They are stout, thick at the base, those of each pair close together at their base; they slowly taper towards the end, and are armed with 12–14 short, thick, blunt, dark spines; at the end of the spine is a remarkable bulbous expansion somewhat chestnut-shaped, being a little flattened and subtriangular, broad at the end, from each side of which arises a small slender tubercle bearing a blunt, stout spine about a third longer than the tubercle. The appendages themselves are dark chestnut, pale amber at base and on the outer third, but the bulbous tip is dark reddish black. Those of the third thoracic segment are very slightly shorter than the pair in front and in each pair the outer spine is the shorter. These horn-like appendages are flexible, especially near the end, and are sometimes bent over and around so as to form a decided bow or curve, or even a nearly complete circle. Compared with those of *Citheronia regalis*, which they most nearly resemble, those of *Eacles imperialis* being forked at the end, the bulbous tips are a little longer, but still of the same general shape and size.

Along the abdominal segments are six rows of very long and slender conical tubercles, giving rise each to a single black seta, which is about a third longer than the tubercle; there are thus six piliferous tubercles on each segment (1–7), the lowest of which, one on each side, is situated just above the base of the legs, and has a double base, sending off posteriorly at nearly right angles to the main tubercle a small lateral one, which emits a black bristle.

On the eighth segment is a very large, stout, acute, bright-red horn, which is borne either erect or directed a little forward; it ends in two long, slender tubercles, each bearing a bristle about as long as the tubercle, and along the trunk are several large spinose tubercles, each ending in a black bristle. The dorsal median tubercle on the ninth segment is broader than long, being transverse, and bears two bristles. The suranal plate is rather narrow, much narrower than long, and ending in two long slender tubercles, each bearing a dark bristle, besides four other bristles. The anal legs are provided with a dark patch on the side and bear long bristles, while there are three black bristles on the base of each middle abdominal leg. There are sixteen (possibly eighteen) crochets on each of the abdominal legs. The body in general is pale green, with a slight yellowish tinge.

There is a median linear dorsal line along the body, and on each side are four narrow dark lines on a green ground, the two middle lines being diffuse, and enclosing a dark band and bearing a row of bristles. The freshly hatched larva spins a silk thread, which after a while is annoying to the observer from its being in the way and adhering to the leaves of its food plants.

The larva, July 17, just before moulting.—Length, 7 mm. The head is now small, black, one-half as wide as the body, which is filled out from five days' feeding. The longest thoracic spines are scarcely one-third as long as the body, and all are pale reddish amber at base and on the outer third, the terminal knobs being black-brown. The caudal horn is also pale reddish amber at base. There is now a definite, broad, white, lateral stripe along the abdominal segments (not appearing in the thoracic), which is bordered above by a dark, thread-like, brownish, spiracular line, enclosing the spiracles which are minute and difficult to detect. Above the spiracular line is a linear distinct white line, and above this is the pale-green subdorsal stripe, diffusely edged on each side with a darker tint. There is a median, small, rounded, amber-colored, dorsal tubercle on the ninth segment, which is double, bearing two bristles. The end of the suranal plate is reddish amber, bifurcate and bearing black bristles. There is a dark patch on the outside of the anal legs.

Stage II.—Moulted July 18 and 19. Length, 10 mm. The head is now high, *slightly angular on the sides;* black-brown with *a light-brown or greenish lateral stripe* on each side, diverging from the light-green vertex to the antennæ, the two stripes varying from pale brown to green. The great spines (both thoracic and caudal) are of about the same proportions and colors as in Stage I, except that the eight thoracic spines, which are still no shorter in proportion to the body, are not so much swollen at the end, the bulb being shorter and broader, and the spines larger, making a more decided fork, and thus resembling those of *Eacles imperialis.* On each of the abdominal segments there is a posterior, transverse row of *six dorsal, distinct, piliferous, conical warts,* there being only two minute ones in Stage I. The anterior series of piliferous tubercles on each segment are now rather large, conical, *the two dorsal ones large and stout,* twice as large as the subdorsal and lateral ones, and all being lemon-yellow (less greenish than before) bearing a terminal black spine, and with a second piliferous tubercle growing out from the side.

The dorsal lines have almost disappeared, there being a subdorsal, pale, almost whitish line, besides a faint, narrow, dorsal, greenish line. *The lateral ridge is now prominent, and bright lemon-yellow,* forming a distinct broken line, bearing in the middle of each segment a very slender, blackish, piliferous wart. A dark reddish purple, narrow, spiracular line; between this and the yellow line is a white stripe and another narrower one above it, while still above is another reddish purple line. Otherwise the markings are the same, the suranal plate, however, is edged with lemon-yellow, being the continuation of the lateral yellow band.

Thoracic and abdominal legs "green tipped with brown" (Jewett).

In this stage upon touching or teasing the larva the thoracic spines spring out, at the same time the head together with the thoracic region jerk violently, as if to beat off an intruder. Also when two caterpillars meet they evidently attack each other, butting and striking with their horns, like two hostile goats, deer or cattle. It seemed evident, after

repeated observations, that the great thoracic spines are of real defensive use.

An examination of Fig. 2 will illustrate better than a prolix verbal description the appearance of the spines in Stages I and II of this species. They are all drawn with the camera, and it is to be observed that the "horns" are more like those of *Citheronia regalis* than *Eacles imperialis*. *a*, one of the horns on the second thoracic segment; *a'*, the extremity enlarged, showing the circular corrugations; *a''*, the same more magnified; *a'''*, a terminal spine enlarged, showing its mode of insertion; it contains a central mass of minute globules; *b*, the first abdominal segment enlarged to show the position of the dorsal, subdorsal, supra-spiracular and spiracular stripes, the latter enclosing the spiracle; also the position of the four spines, one dorsal, one subdorsal and two infraspiracular; the spines are all minutely barbed; *c*, a dorsal spine, bearing a spinule at its base; *d*, "caudal horn" or medio-dorsal spine on eighth abdominal segment; ix, that on the ninth segment; it is small, conical and forked at the end, each fork bearing a long seta. All the foregoing in Stage I. *f*, a "horn" from the second thoracic segment, Stage II; the two terminal spines have entirely changed in shape, being larger and longer, and bearing a tapering fine bristle; a third smaller conical tubercle has appeared near the base of one of the forks. The spinules on the trunk now bear a bristle; *e*, "caudal horn" of Stage II; now large and high, deeply forked at the end; the spines or tubercles on the trunk of the horn now bear each a slender bristle.

Stage III.—Molted July 26, 27. Length, 13–15 mm. The head is now high, the face subtriangular, not black as before, with a green lateral stripe, but *pea-green with a yellow stripe on each side*, shaded more or less with black between the yellow V; and on the outside, in one example, the black is reduced to a diffuse patch inside, while in another larva it is outside of the yellow V. The head is now nearly as wide as the body.

The eight horns are still nearly half as long as the whole body and are now paler than before, being reddish chestnut and yellow at base, with black spinules and blackish at the tips, which are now not bulbous, only irregularly forked. The spines along the body are larger and stouter than before; the tubercles at base are deeper yellow than before, tipped with black, while the high, conical or (sometimes) rounded granulations are snow-white. The lateral yellow stripe along the body is more distinct than before; it is bordered above with pure white, and above this is the linear dark purple spiracular line, shaded above more distinctly than in the preceding stage with deep blue-green or verdigris green; the caudal horn as before being pink, with white spines bearing black bristles. The larva also differs from that of Stage II in the suranal plate, which is more deeply forked, *the forks being thicker, larger and with several tubercles;* the sides of the plate are heavily spined and on the surface are about six central, small, conical spines. Now the dorsal abdominal

spines are *distinctly ivory-white on the outer side from the base up to the dark tip.* The spiracles are much larger than before, distinctly interrupting the dark purple spiracular line which is paler than before.

Stage IV.—Molt not seen, but it probably occurred August 1 or 2. Length, 25–28 mm. The head is, as before, with two yellow stripes, one on each side, and bordered more or less on each side, especially in front, with black. *The four pairs of thoracic horns are now but little longer than the body is thick* and are reddish flesh-color, dark at the slender forked tips, and yellowish green at the base.* *The "caudal horn" is now considerably shorter in proportion than before, being about two-thirds as long as the body is thick,* and is of the same peculiar deep flesh-red as the thoracic horns. The sharp, stout, spine-like tubercles on the fourth and sixth abdominal segments are slightly over twice as large and thick as the other dorsal tubercles which are as in the previous stage, and bear a verticil of from three to five short blunt spinules; *they are now silvery white on the outside* (Jewett says burnished silver). The lateral yellow, carmine, white and blue bands are much as before. The increase in size of this stage over the preceding one is noticeable.

In his account of this stage Jewett states that the head is "green, bilobed, minutely pubescent," also that the thoracic horns had lost their knobs at their extremities; but this appears to take place at the time of the second molt.

In a larva 20 mm. long, and probably of this stage, the lateral band is tricolored, marked below with straw-yellow, the yellow enclosing the base of the black spines. Jewett says: "The legs of some larvæ are green and of others brown. Prolegs of some green and in others green tipped with brown. In some larvæ the stigmatal space has numerous small, black tubercles on each segment; in others there are no black tubercles."

The following description of another larva, drawn up October 10, and probably in the fourth stage, may be useful.

Stage IV (?)—Length, 24 mm. Body rather thick. Head remarkably Sphinx or Smerinthus-like, as wide as the body, flattened in front, broad below about the mouth, but narrowing towards the vertex, as in Sphinx; the skin rough; with two lateral, rather broad, yellow lines, which arise from the base of the antennæ and converging nearly meet on the vertex; across the upper division of the clypeus is a blackish band which adjoins a black blotch on each side, and which touches the yellow line. Labrum pale yellowish, blackish in the middle; eye-patch and mandibles black.

Prothoracic segments very slightly wider than the rest of the body in front; the front edge flaring and rising up somewhat collar-like; this edge armed with a single row of white tubercles, about ten on each side of the segment, those above nearly adjoining at base and tinged with

* Jewett says the spines are "brown in some larvæ and green in others."

yellow; those on the sides below pure snow-white; behind the front edge are four small but distinct white warts, two in the middle.

The second and third thoracic segments each with two widely separated pairs of horns, not quite so thick as the caudal horn, each about two-thirds as long as the segments bearing them are wide; they are slightly recurved and scattered over them are conical white tubercles which are irregular and blunt at the end; they are yellowish at base, near the middle becoming dark pink and at tip reddish black-brown. On the front edge of the second thoracic segment between the horns is a row of three conical sharp tubercles, with a similar and some minute ones on each side, while on the third segment are two similar white warts.

Across the dorsal side of the abdominal segments 1–7 are two rows of white, sharp, conical tubercles; two of those on the front edge of each segment being longer and sharper than the others and directed backwards. On these same segments (1–7) is a third set of curious tubercles, mostly large conical and black internally, but on the outside shining opalescent pearl or silvery white, and resplendent, glittering brightly by lamplight. Of these curious spines those on the first abdominal segment are smallest, and those on segments 4–6 are largest, being about one-third as long as the caudal horn; the pair on segment 6 being the largest. The "caudal horn" on the eighth segment is large, with a few white tubercles, those at the end of the horn being reddish; the tip is slightly forked, there being two minute tubercles; all those on the sides of the horn bear a short fine hair. In the middle of the ninth abdominal segment and in a position homologous with the caudal horn, is a minute, short, median, white wart, which is reddish at the base. The suranal plate and hind legs are very large, the surface rough and heavily warted, especially on the edges; the lower edge of the anal legs and suranal plate are interrupted with black. The eighth and ninth segments and base of the suranal plate are a little wider than the middle abdominal segments. The suranal plate is a little longer than wide, subacutely triangular, the tip forked and ending in two rather large tubercles, which are greenish at the end, blackish at base, with a little transverse median black stripe in front.

The stigmata are deep flesh-colored, with a slit in the middle, whitish, especially at the end. The stigmatal line along the side of abdominal segments 1–8 is whitish, edged above with purple, and still above washed irregularly with livid greenish blue, while from the eighth segment to the tip of the suranal plate the line is straw-yellow. Below, near the base of the feet, is a lateral row of sharp black spines; there are several on the sides of the thoracic segments and one rather large one under each spiracle, with smaller sharp ones below. The thoracic legs are black; the middle abdominal legs large, greenish, with two or three alternating rows of sharp black spines near the base, and also with fine white tubercles like those on the rest of the body. Along the middle of the under side of the body the skin is immaculate green.

Stage V and last.—Length, 35–38 mm. (Jewett says from two to two and a half inches when fully grown). The head is now not angular but rounded, though slightly narrowing and produced above; dark pea-green, considerably darker than the body; with a broad yellow band beginning on the antennæ and fading out on the vertex. The ocelli are black; the mandibles black; the anterior lobes of the labrum brown, including the palpi. The head is about two-thirds as wide as the body, the surface covered with fine minute granulations arranged in groups (only seen under a strong Tolles lens).

The body is thick; the prothoracic segment short, and not so wide as the second thoracic segment. It is unarmed, its front edge with a transverse series of white bead-like warts set close together. Behind, the body is thick, being of the same thickness as far as the eighth abdominal segment. Second and third thoracic segments each with two pairs of very large spines which are about two-thirds as long as the body is thick; the outer one of each pair is slightly shorter and slenderer than the inner, but those of both pairs are alike in size; they are roseate, pale coral-red and not so near in tint to the spines of the food-plant as in the young; when the caterpillar is at rest they are held close together in a recurved position and in the grown-up larva when touched they are not moved or the body jerked in response to such stimulus. They are adorned with white blunt spines, which are often tipped with black.

"The 'silver horns' on the fifth to the tenth segments are now one-sixteenth to one-eighth of an inch long, bright pink inside and burnished silver externally. The number of these 'silver horns' varies in different larvæ, some having them only on the seventh and ninth segments; others have them on the fifth, seventh and ninth segments; still others have them on the fifth, seventh, ninth and tenth segments" (*Papilio*, ii, 49). "I have now to add that this year I reared three larvæ having these silver horns on every segment except the twelfth; still the imagines from these three larvæ did not differ from the ordinary form" (Jewett, *Papilio*, ii, 144).

The horn on the eighth abdominal segment is now only about one-fourth shorter and thicker than the thoracic spines, and is of the same color and structure, the spinules being conical, rounded, blunt, white, and bearing a fine bristle.

On abdominal segments 1–7 are two dorsal rows of acutely conical spines, which are recurved and directed backwards. Those on the fourth and sixth segments are twice or thrice as large as those on the other segments (1–3 and 4 and 7) and provided with three or four blunt spinules; the spines themselves are roseate on the inner side, and externally brilliantly painted with a pearly silvery white, giving off all the colors of the rainbow during the movements of the animal. The corresponding spines on the other segments are painted in the same fashion though less brilliantly.

On the side of the body from the third thoracic horns to the eighth ab-

dominal spiracle is a bicolored stripe; it is pure marble-white below, and above rosy purple, and is interrupted by the wax-colored spiracles, which extend above the upper limits of the reddish line. The suranal plate is very large and long, deeply divided at the end, the two forks being, like the surface, coarsely granulated with stout short conical spines; the plate is green, with the edge straw-yellow. There is a minute median spine on the ninth abdominal segment. Each abdominal segment with two dorsal transverse rows of white, bead-like, coarse granulations. Below the bicolored lateral stripe is a black, double, conical spine on each segment, and underneath on abdominal segments 1, 2, 7 and 8 is a group of unequal, smaller, black, sharp spines. The body beneath is granulated with white, and also on the sides, as well as above.

The thoracic legs are black, partly greenish beneath; the abdominal legs, including the anal pair, are greenish, with a group of singular black piliferous spines, while some of the spines are tipped with white.

The general color of the body is of nearly the same hue as the under side of the leaves of the honey-locust, and thus colored it is partly assimilated and protected by its color, while the horns are in general like the spines of its food plants. On the other hand the gleaming silvery spines certainly render the creature conspicuous, as well as the lateral parti-colored band.

It would appear probable that the formidable spines of the grown-up caterpillar save it not infrequently from being swallowed by birds; though the horns are probably of greater use in the earlier stages when they are much longer and much more movable, in frightening away ichneumons and Tachinæ. For example, even when 20 mm. in length, a larva was seen when teased to spread apart its great arm-like horns, while the full-fed ones did not notice such stimulus.

Summary of the salient Features in the Ontogeny of Sphingicampa bicolor.

A. Congenital Characters of the Larva; all appearing in Stage I.

1. The two pairs of enormous spines of second and third thoracic segments one-half as long as the body, and ending in a two-spined, large, flattened, dark bulb; freely movable and plainly defensive in function.

2. The large, reddish, spiny "caudal horn," on the eighth uromere, ending in two bristles.

3. The double piliferous tubercle on the ninth uromere; becoming obsolete in Stages IV and V.

4. The abdominal region is longitudinally striped with dark and whitish bands, but there are no transverse marks in Stage I or in later stages.

B. Evolution of Later Adaptational Characters.

1. The head slightly angular, face subtriangular, with a light brown or greenish lateral stripe (Stages II–V).

2. Appearance of a transverse row of dorsal granulations on the hinder end of each segment in Stage II, persisting through larval life.

3. The eight thoracic spines lose their bulbous tips, and become simply slightly forked in Stage III, and later.

4. The two dorsal spines of uromeres 1–7 are in Stage II larger than the others; in Stage III they become ivory-white externally, and in Stage IV larger and silvery white on the outside.

5. In the last two stages the eight thoracic spines become very much shorter in proportion to the size of the body and become less movable; as they decline in size and functional importance, the metallic, silvery, dorsal spines on the abdominal segments become conspicuous and apparently useful to the larva.

One larva, 36–37 mm. in length, ceased feeding August 7, and began to pupate, but I did not carry any into the pupa stage.

What Dr. Jewett means by saying that "the larvæ change only in size during the last moult," we do not understand, as the increase, so far as we have noticed, is gradual from Stage I to V, as in other larvæ. The brood which Dr. Jewett raised in Ohio, "began to quit feeding on the 20th of June, entering the ground within a few hours after ceasing to eat. Then they pupated within an oval cell lined with a thin cocoon of silk, the first casting its skin on the 24th. The pupa is at first bright green, but changes to jet black in a few hours."

"Imagines began to appear on July 3, and had nearly all emerged by July 10. The insect is three-brooded here, hibernating in pupa. Although the large majority of each brood follows the cycle of development as described, yet a few of each brood are much slower in making their changes. Thus a few of the brood did not complete their growth till the end of July, and three pupæ, formed June 26, are still alive (February 28), having hibernated. Other pupæ of the same brood disclosed their imagines at various periods during July and August. This accounts for the fact that larvæ in all stages of development may be found at any time throughout the summer till frost kills their food-plants" (Jewett).

Remarks on Sphingicampa bicolor.—This is the most Sphinx-like of any Ceratocampid or other Bombycid I know, resembling sphingid caterpillars in the following characters:

1. The shape of the head and its markings.

2. The four thoracic horns (like those of Ceratomia) perhaps a case of reversion in the latter.

3. The caudal horn.

4. The large, square, heavy anal legs.

5. The skin granulated with small white tubercles.

One can, when we take into account the larvæ alone, well imagine that the Sphinges are, as claimed by Mr. E. B. Poulton, descended from the Ceratocampidæ, though these may be only adaptative characters, and not applicable to the imagines, which differ in venation, in the tongue, and in the proportions of the head pieces.

The horns in Sphingicampa are not held spread out as in *C. regalis*, but those of each pair are constantly held close to each other. The horns and the six silvery, opalescent, shining tubercles probably become terrifying by the movements of the larva. The latter are turned on and throw their light out suddenly like flashes and may thus have a deterrent effect on their enemies.

Life History of Eacles imperialis (Drury).

The eggs were received from Mr. James Angus, and the larvæ hatched from them reared in Maine, so that their development, owing to the cooler climate, may have been less rapid than in New York, where the eggs were laid.

Egg.—Length, 3 mm.; breadth, 2.5 mm.; thickness, 2 mm. Flattened elliptical, each end alike, white, with an equatorial, smooth, distinct ridge. The shell is white, the surface under a high-power triplet is seen to be finely pitted, the pits being shallow and not closely crowded. Under a half-inch objective the pits are seen to be shallow, and not often with a definite raised edge; often there is a boss or bead in the centre. Arising from the spaces between the bosses are slender, short, very minute hairs, originating from a swollen base. Under a one-fifth objective, as well as a one-half and a triplet, I cannot distinguish between the microscopic structure and markings of *imperialis* and *regalis*.

The Freshly Hatched Larvæ.—Some were seen drawing themselves out of the shell June 30, at noon. Length in a few minutes after hatching 7–8 mm.; width of head, 1.5 mm. The tubercles and spines become erect before the larva entirely deserts the shell.

The head is large and full, smooth, shining, nearly twice as wide as the body behind the middle, but the prothoracic segment is much wider than the body; the prothoracic segment is above of the same color and the surface shines like the head. The body is pale chestnut, with a slight pinkish tint. All the spines are, before it entirely leaves the egg, shining jet-black; the five longest ones (four thoracic and one median abdominal) bearing white hairs, the end hairs on all the shorter ones being black. The thoracic segments are without transverse dark stripes, but on each of abdominal segments 1–7 there are three transverse, distinct, conspicuous, black dorsal stripes; the first one in front of the spines is broken, and wanting on the first abdominal segment; but the two behind are unbroken and extend a little below the position of the spiracles. The spiracles are hard to detect as they are situated on an oblong or fourth transverse black band between the two lateral spiracles. The eighth and two last segments are not banded. The large anal legs are edged with black behind. The thoracic legs are black.

There are four spines on each side of the prothoracic segment, all of very unequal length; the lowest one minute and bifid; the one in front of the spiracle stumpy and ending in five slender, papilliform, piliferous

tubercles. The subdorsal one is much longer and forked, while the two dorsal ones are very long and slender, about as long as the head is broad and deeply forked, each fork bearing a bristle. *The two dorsal tubercles on the second and third thoracic segments are enormously long and very slender*, being about half as long as the body. They are deeply forked, each fork long and slender, and bearing a long bristle. The tubercles on abdominal segments 1–7 are small and short, of nearly equal length, simple except those of the infraspiracular row, which are deeply forked. The single median tubercle on the eighth abdominal segment is remarkably long and slender, about two-thirds as long as the thoracic ones. *There is also a single median forked tubercle on the ninth segment*, not half as long, however, as the one directly in front. *The suranal plate bears at the end two long five-branched piliferous tubercles.* All the tubercles are of nearly the same color as the body, the five longest ones, however, a little brownish near and at the end.

The four middle pairs of abdominal legs are shining black externally on the outer half; otherwise they are concolorous with the body.

The following description is drawn up from some larvæ at the end of Stage I, living October 9 or 10 and reared by Mr. Bridgham: they were about 7 mm. in length and had been kept for a number of days and died before molting. The head is large, full and rounded, smooth and shining honey-yellow; nearly twice as wide as the body (actual width, 1.5 mm.), rounded above on the apex; the eyes and mouth-parts black; labrum whitish. The body is ochreous. The prothoracic segment is very broad and flaring in front, nearly as wide as the head, bearing ten black spines, of which the two dorsal ones are about as long as the body is thick, each bearing three or four small, short tubercles, and ending in a long fork, each branch bearing a long seta which is white at the base. The subdorsal spines are a little less than half as long and large as the dorsal ones. The dorsal second and third thoracic horns are very long and large, being nearly twice as long as the middle of the body is thick; the stalks are knotted (not tuberculated), and deeply forked at the end; each fork thick and ending in a seta. Those on the third segment are slightly shorter with a smaller fork than the two on the second thoracic segment. Each abdominal segment is provided with six black spines; the two dorsal ones about half as long as the body is thick, with two or three minute warts; they are forked at the end, the lower fork small, about as long as the spine is thick, and not bearing a seta, while the other fork or tine is directed obliquely upward.

The spines of the next row outside (subdorsal) are small and simple, while the lateral row near the base of the legs is composed of branched spines nearly as large as the dorsal ones, and with each branch ending in a long seta. The caudal spine on the eighth abdominal segment is nearly as large as those on the second and third thoracic segments, but with a smaller fork, each ending in a seta. There is a median dorsal spine on the ninth segment, about one-half as long and large as that on the eighth,

with three branches, the two terminal forming an uneven fork. There is no distinct suranal plate, only a subtriangular flattened area bearing along the edge six black spines of very unequal size. Around abdominal segments 1–7 is a double, black band, and the lateral and subdorsal spines on these segments are connected by a black band, also enclosing the spiracles; these short bands alternating with long bands passing over the body. The thoracic legs are black; the abdominal legs dull ochreous, with a large, black patch covering the outside. The anal legs are rather large and square, ochreous, the hinder edge pitchy red.

It may be observed that the median dorsal spines on the eighth and ninth abdominal segments are forked like those of *H. io;* this and *H. maia* being apparently earlier forms.

Stage II.—July 10, 11. Length, 13–15 mm. The head is as wide as the thoracic segments (exact width, 2 mm.); it is chestnut brown, a little darker on the sides above the eyes and on the clypeal region. The spines on the prothoracic segment are much as before, *but stouter and shorter.* The dorsal spines on the second and third thoracic segments are much as before *but not quite so deeply forked;* they are dusky amber wax at the base, and black beyond; they are irregularly spinose from base to tip; each fork bears a white hair. *All the other spines are black.* The "caudal horn" on eighth abdominal segment is stouter at base, the trunk with larger, longer and more numerous spinules, which end in a bristle which is not present in Stage I; it is still evenly forked.

The subdorsal spines are now much shorter than before and simple and conical; while the lateral series, instead of being nearly as long as the dorsal ones and deeply forked, are short and stout, ending in three short, stout, piliferous spines.

The body is now dull chestnut, with dusky discolorations, but *without the decided black bands and spots of Stage I,* the body being decidedly darker. The black spiracles are surrounded by a diffuse black ring. The thoracic legs are black; the middle abdominal legs jet-black outside, on a chitinized portion; the anal legs are of the color of beeswax, with a jet-black spot or wart at the tip, and a dusky patch on the sides; these black plates are *larger and longer than in Stage I.*

The descriptions of Stages III and IV were drawn up from a series reared at my request by the late Mr. S. Lowell Elliott and preserved in alcohol; the colors are described from a set of drawings by Mr. Bridgham. Mr. Elliott observed five stages.

Stage III.—(Preserved the third day after the second molt.) Length, 30 mm.; width of the head, 3 mm. The head is narrow, about one-half as wide as the second and third thoracic segments; chestnut brown with two pale, longitudinal bands in front, each band ending at the base of the pale antennæ. *The two dorsal spines on the prothoracic segment are much shorter* than in Stage II, with much stouter lateral spinules, and with shorter forks at the tip, and the spines on the trunk are shorter. The two second thoracic dorsal spines are a little stouter than before, but are

nearly as in Stage II, and are spinulated in the same way; they are 4.5 mm. in length; they are pale on the basal half and dark brown on the distal half; the corresponding spines on the third thoracic segment are a little shorter. *The dorsal and lateral spines on abdominal segments 1–7 are much smaller* in proportion than in Stage II, the dorsal spine being still unevenly forked. The "caudal horn" on the eighth segment is now 3 mm. in length, and is still regularly forked as before. *The corresponding single median spine on the ninth segment is minute and much smaller than before.* The two larger spines on the suranal plate *are smaller than before*, each bearing four spines, and behind these on the edge of the plate are four minute conical spines; the plate is regularly rounded behind; it is dark brown in the middle, with paler rounded granulations. On the side of the anal legs is a similarly ornamented *distinct, narrow, triangular field not developed in Stage II.* The middle abdominal legs are tipped with black as before. The body is more hairy than before.

The general hue of the body is at first pale yellowish brown (raw sienna), with a large pale area around the dark spiracles. There are no distinct markings. Towards the end of the stage the body in those feeding on white pine becomes decidedly reddish, and in fact the color varies from violet through all shades of golden brown and orange purple to black. The horns are rosy-red at base; there is a broad, pale, diffuse, subdorsal band on each side and the dark spiracles are rendered very conspicuous by the broad yellowish ring around them.

Fig. 3.—Armature of *Eacles imperialis.* Stage I. *a*, a dorsal prothoracic spine; *b*, a subdorsal prothoracic spine; *c*, a dorsal spine of the second thoracic segment; *d*, a dorsal spine of the third thoracic segment; *e*, the first abdominal segment, side view, showing the anterior and posterior black band, and the position of the dorsal, subdorsal and infraspiracular spines with the spiracle; *f*, the suranal plate, in part, bearing the anterior spine, ending in four setiferous tubercles and the two smaller, simple spines at the end of one side of the plate; *g*, the "caudal horn" or medio-dorsal forked spine of the eighth uromere, seen partly from the side; *g'*, end of the same, seen from in front, showing the two forks; *h*, one of the dorsal spines on the ninth uromere; all drawn with the camera to the same scale.

Fig. 4.—Armature of *Eacles imperialis.* Stage II. *a*, end of one of the dorsal prothoracic "horns;" *b*, one of the dorsal second thoracic "horns;" *c*, the "caudal horn," or medio-dorsal spine on the eighth uromere. Stage III. *d*, one of the second thoracic "horns;" *e*, the "caudal horn" or medio-dorsal spine of the eighth uromere. All drawn with the camera to the same scale.

Stage IV.—(Four days after the third molt.) Length, 40 mm.; width of the head, 4.5 mm. The characters of the full-grown larva are now nearly assumed. The head is, in one specimen, twice banded with pale yellowish in front, in another the bands are nearly obsolete and the head almost entirely dark chestnut. The two dorsal prothoracic tubercles are now

very short, not so high as broad, and end in a group of rounded conical spinules; those on the side of the same segment having the same general shape. *The second and third thoracic segments, with the dorsal horns, now much as in the full-grown larva,* though a little slenderer; length, 5 mm.; they are more curved than before and directed backwards and provided with numerous dense conical tubercles; they are pale yellowish at base, and rosy on the distal half, becoming black at the tip, which is still regularly forked; the two pairs are of the same shape and length. The abdominal dorsal spines are much stouter and shorter in proportion than in Stage III. The subdorsal (supraspiracular) spines are simple, conical; the lateral (infraspiracular) spines are very short, and composed of four spines. *The "caudal spine"* (single median dorsal spines on eighth abdominal segment) *is now much stouter, more conical than before;* 2.5 mm. in length and furnished with crowded spines, but still ending in a regular fork. The suranal plate is as before, but the spines are shorter, and the exterior of the anal legs are ornamented as before.

The hairs are now long and abundant, some of the dorsal ones longer than the body is thick. The spiracles are very conspicuous, each being surrounded by a broad green ring, outside of which is a yellowish ring, which is margined with yellowish brown. The body is dark umber-brown; the reddish spines and the spiracles, as well as the reddish edges of the suranal plate and anal legs, decidedly contrasting with the dark hue of the body. The color of the spiracles varies in different individuals, being sometimes mostly white or green or red. Also the yellow color around it is sometimes large and of different width, sometimes being reduced to a line.

The last stage differs from Stage IV in the shorter dorsal horns and caudal horns, those on the sides also being decidedly shorter, and the anal legs are larger, with a wider dark granulated area on the sides, and the body is much thicker and heavier, while the head is pale.

Last (Fifth) Stage.—Length, 10 cent. (Described from one living on the choke cherry.) Head one-half as wide as the body; width, 7 mm.; deep gamboge-yellow, and green on the side; a double deep black frontal line extending from the vertex, diverging below so as to leave a median yellowish line on the upper division of the clypeus. The front division of the clypeus (clypeus anterior), the antennæ, and the base of the jaws yellowish. The thoracic legs and the horns on the second and third thoracic segments and the anal legs with the suranal plate are all of the same color, *i. e.*, deep shining gamboge-yellow. The general color of the body in the green individuals is a delicate pea-green (more usually the individuals are brown or tawny), varying from the shade of the upper side of the cherry leaf to that of the under side, being paler above along the back and especially on the sutures than on the sides. The hairs are long and slender and whitish, most of the dorsal ones as long as the body is thick. There is a prothoracic plate of the same green hue as the body, but with yellowish edges. Of the four horns on the second thoracic seg-

ment, the outer ones are half as long as the inner or dorsal ones, which are 4.5 mm. in length; those of the third thoracic segment are of the same size as those on the second. There are four similar but much smaller dorsal and subdorsal horns on each of the abdominal segments (but they are shorter and more regularly conical than in Stage IV), those on each segment being of the same size, the two dorsal ones being almost three times as large as the subdorsal ones, each dorsal one bearing three terminal spines. Those on the thoracic segments are tuberculated, ending in a fork. On the eighth abdominal segment is a median dorsal horn, now shorter in proportion than in Stage IV, small and short, length 2 mm., nearly twice as large as the other dorsal ones in front, tuberculated and slightly forked at the end, but not so regularly forked as in Stage II. There is a minute median one on the ninth segment, and two minute lateral ones on each side of the segment. The spiracles are very large and conspicuous, yellow with an outer ring of very dark green, which is edged on each side with paler green; those on the prothoracic segment are without the deep-green outer ring. The suranal plate is regularly triangular, gamboge-yellow, with a swollen, rough, coarsely granulated edge, within which the surface is black, with yellow coarse granulations. A similar narrow triangular plate on the anal legs. The middle abdominal legs dark pea-green, with a deep ochre-yellow transverse band above the black planta.

For a careful description of the egg and the larva in its first four stages see Dr. J. A. Lintner's *Ent. Contr.*, ii. 150. His larvæ molted four times, and he thought from the small size of the specimens after the fourth molt, that there might be a fifth one.

The fifth and last stage differs from Stage IV in the shorter dorsal horns and "caudal" horn; the tubercles on the sides of the body also being decidedly shorter, while the anal legs are larger, with a wider, dark, granulated area on the outside. The body is also thicker and heavier, while the head is paler.

It is noticeable that in this form, as in the Attacinæ, there is a great increase from one stage to another in the size or bulk of the body, while the head does not increase in a corresponding ratio.

SUMMARY OF THE CHIEF ONTOGENETIC FEATURES.

A. *Congenital Characters.*

1. In Stage I there are three pairs of very long dorsal deeply forked thoracic horns, nearly half as long as the body.
2. A similar median spine on the eighth abdominal segment, with one half as long on the ninth.
3. The abdominal segments are transversely banded with black.
4. The lateral spines on the abdominal segments bifid and nearly as large as the subsimple dorsal ones.
5. Body pale chestnut brown; head light reddish.

6. The spiracles minute and difficult to detect, as they are situated in one of the transverse black bands.

B. *Evolution of Later Adaptational Characters.*

1. The forks of the larger dorsal spines disappear at the end of Stage III.
2. The dorsal thoracic spines become recurved in Stage III.
3. The dorsal thoracic and caudal horn become much shorter and stouter in Stage IV, when the characters of Stage V (and last) are nearly assumed.
4. In Stage II the dorsal spines on the prothoracic segment begin to grow shorter and stouter.
5. In Stage II the large horns begin to be less deeply forked.
6. The transverse black stripes disappear at the end of Stage II.
7. The dorsal and lateral spines on abdominal segments 1–7 are much smaller in proportion in Stage III than in Stage II.
8. Towards the end of Stage III the colors of the body become more conspicuous and variable.
9. In Stage III the spiracles become particolored and very conspicuous.
10. The dorsal thoracic and the "caudal horn" become much shorter in Stage IV, and not forked at the tip.
11. The hairs become long and abundant in Stage IV.
12. The body in Stage IV becomes much stouter and heavier than before, while the head has not greatly gained in size proportionately.

Life History of Citheronia regalis (Fabr.).

For the eggs I am indebted to Miss Morton, who sent them June 25 from New Windsor, N. Y. They hatched July 11. The eggs being indistinguishable in size, shape and color from those of *E. imperialis*, the reader is referred for a description to those of the latter insect. The egg-shell is so transparent that just before the larva hatches it can be seen lying curved up on its side. The head is large and black, while the body is pale, with distinct yellow sutures. Also the black thoracic legs are visible, and the black spots, those on the thoracic segments, elongated; also the dark spines and certain large ochreous patches on the thoracic segments.

Larva, Stage I.—Length, 6 mm. The head is large, wider than the body, smooth and shining black all over, with a few fine dark hairs. The body is cylindrical, black all over, with no stripes or spots of a lighter hue. A pair of large, long dorsal horns on the first thoracic segment, ending in a peculiar bulbous swelling, and on each side of the segment is a smaller subdorsal spine one-third as long as the dorsal ones, which is simple at the end, tapering to a point, bearing a short tine near the middle, and ending in a stout bristle. On each of the second and third thoracic segments is a pair of dorsal horns on each side, or four to each segment. The outer or subdorsal horns are only a little more than half as long as

the inner, but otherwise like the latter; the trunks are spiny, the spinules minute, sharp, nearly equal in size, there being about fifteen to each trunk or stem of the spine. The singular bulbous termination is flattened, rather deeply divided, but somewhat like a chestnut in shape, but wider in proportion, and each side is produced, ending in a blunt spinule, with a stout thick base; the trunk is umber-brown, but the bulbous extremity is blackish brown.

On being touched the larva jerks its head and front body sideways vigorously.

Each of abdominal segments 1–7 has a pair of smaller sharp spines about one-third as long as the longest thoracic spines, which are bent just beyond the middle where it sends off a spur; the end bearing a stout, not very long bristle. Besides these there is a pair of subdorsal spines and a lateral smaller one situated above the insertion of the legs, or six spines to a segment. There is a single median spine on the eighth segment just like the shorter outer ones on the thoracic segments in shape and color, and ending like them in a forked bulbous expansion. Also on the ninth segment is a smaller, shorter, single median dorsal spine, but regularly forked at the end, not swollen. On the tenth segment near the base are two stout, short spines, ending in four branches. Behind them at the end of the suranal plate are four minute spinulose piliferous spines, which are black, all the others in front being brown. The large, broad, squarish anal legs are corrugated on the side. All the legs, thoracic and abdominal, are black. The specimens died before molting.

Fig. 5.—Armature of *Citheronia regalis*. Stage I. *a*, the first abdominal segment, showing the relative position of the spines; *sp*, spiracle; *b*, one of the dorsal prothoracic "horns;" *c*, one of the dorsal horns of the third thoracic segment; *d*, one of the dorsal abdominal spines, those on segments 1–6 not differing in size or structure, near the base are two minute blunt setæ; *e–h*, the armature of the last three abdominal segments; *e*, the caudal horn; *e'*, the subdorsal spine of the same (eighth) segment; *f*, one of the dorsal spines of the ninth segment, which is evenly forked at the end; *g*, one of the large lateral spines arising from the suranal plate (x); *h*, the end of the suranal plate. All the figures drawn with the camera to the same scale.

The following description is drawn up from specimens bred at Providence, and described October 10. They fed on hickory, and were sent to Mr. Bridgham from Georgia.

Stage II (?).—(Probably Stage II, as the increase in size between the later stages is very marked.) Length, 25 mm. The head (width, 2.8 mm.) is rather large, rounded, as wide as the body, smooth and shining, mahogany brown, with two faint black shades converging towards the apex. The body is somewhat slender, the skin smooth and dull flesh-brown, with smoky blackish marks, the spines and spinules a little paler than the body and tipped with black. The prothoracic segment is broad, the front edge raised and flaring, with a transverse row of six black spines,

four dorsal and one subdorsal; of the four dorsal the inner two are about as long as the body is thick, and sharp at the end, with long spinules; the two adjoining spines are minute. The four spines on the second thoracic segment are much larger, the outer ones on the second and third thoracic of nearly the same size, but the inner two on the third thoracic segment are a little longer than those on the second.

The spines on abdominal segments 1–8 are of even size, and armed with long spinules; they are about two-thirds as long as the body is thick, and end in two long diverging spinules. On the eighth segment, arising from a large, fleshy base, is a much spinulated caudal spine, nearly half as long as the large thoracic ones; it is mostly black, but flesh-colored in the middle. Behind it, on the ninth segment, is a median dorsal horn, about one-third as large as that on the eighth.

The suranal plate is small, rough, bearing two large spines; the end is rounded, with two minute spines between the last pair of lateral spines; the anterior two of the spines on this plate are larger, but simpler than those on the ninth abdominal segment, and end in four spreading spinules, the main stem being nearly smooth.

The prothoracic segment is blackish, reddish dark flesh color in the middle; the second thoracic segment is of nearly the same color, but the third is entirely black. The stigmata are black, surrounded by a blackish cloud, while in front is a velvety black oblique dash, and beneath a flesh-colored oblique raised ridge or fold. All the legs, both thoracic and abdominal, are black; the anal pair are large, rough and black. There is a large spine under each spiracle.

Stage III.—Length, 30–35 mm. Molted on the morning (9 A.M.) of October 10. When first seen the color of the body was uniformly purplish flesh color, with black markings. The head (width, 4 mm.) is dark chestnut brown, with the clypeus and adjoining parts pale. *It differs from the preceding stage in the considerably shorter abdominal spines, while their spinules are somewhat larger in proportion than in the previous stage.* The thoracic spines are about, or a little more than, twice as long as the body is thick, and the abdominal spines are about one-third as long as the body is thick. The lateral oblique fleshy fold on the abdominal segments have a more distinct dark dash above than in the preceding stage. The legs are black. The caudal spine is now about one-third as long as the larger thoracic ones, being in the former stage about, not quite, one-half as long as the longer thoracic spines.

By 2 P.M., October 10, the thoracic and caudal spines, at first pale flesh color, became black, and the head and thorax, as well as the body generally, had turned darker.

It assumes, like *E. imperialis* and *S. bicolor*, a Sphinx-like attitude, so that this feature is possibly inherited by the Sphingidæ from the Ceratocampidæ or a similar group. The thoracic and caudal spines are somewhat sensitive to touch by an intruder.

Last Stage.—I will first describe an alcoholic specimen, 45–50 mm. in

length, which at first I thought must belong to a fourth stage, or at least one before the last, but as the head is of nearly the same size as full-grown specimens, I am inclined to regard it as simply a belated individual, or one which had recently molted, and had not fed up so as to fill out to its full size.

Length of body, 45–50 mm.; breadth of the head, 6.5 mm. The head is yellowish brown, with a dark spot on each side of the head opposite the apex of the clypeus. The two dorsal prothoracic spines are nearly as long as the head is wide, but without the long slender spinules of the previous stage; they are yellowish, but black on the distal third; the third or metathoracic pair are a third longer than the body is thick, and like the others, with short, stout spinules. The abdominal spines are now much shorter than before, with short spinules, though slightly longer than in the fully grown examples. The "caudal spine" on the eighth abdominal segment is as in the full-sized specimens. The general hue of the body is as in the full-grown larva, but the thoracic dorsal black spots are smaller, though the metathoracic segment in front of the horns is deeply stained with black.

Full-grown Larva.—Length, 125 mm.; thickness of the body, 20 mm.; width of head, 7 mm. The head is about one-third as wide as the body rounded, smooth, free from hairs, and yellowish, not spotted on the sides, and not banded as in *Eacles imperialis*. The body is cylindrical; the skin smooth and shining, not granulated, as in Sphingicampa and Eacles. The two middle prothoracic spines are large and long, being nearly as long as the head is wide, but the spinules, like those of the other "horns," are now short, thick and acute, not long and slender as in the previous stages; length, 6 mm.; they are yellowish and black on the outer third. This and each segment of the body succeeding have six well-developed spines, except the eighth and ninth abdominal, which have each an additional spine, the large median one. The two large median horns on the two hinder thoracic segments are each about 20 mm. in length; the horns of the second row corresponding to the subdorsal or supraspiracular row of the abdominal segments, being about half as long (10 mm.) as the dorsal ones; they are also yellowish and blackish on the outer third. All the six abdominal spines of segments 1–7 are now very small, slender and only about twice as long as the large dorsal horns are thick at the base; viz., 4 mm. in length. Unlike the full-grown Eacles, the supra and infraspiracular spines are as well developed as the dorsal ones. On the eighth and ninth abdominal segments the "caudal horns" are supplemented by two small, slender spines, situated just behind the large median horn. Whether these have any morphological significance is doubtful; they do not exist in Eacles. Length of the "caudal horn" on the eighth segment, 9 mm.; that on the ninth segment being one-half as long. The suranal plate is triangular, the surface rough, with two small tubercles on each side, but no spines. The anal legs are very large, subtriangular, with the outer surface rough, and on the

lower edge above the planta is a group of seven or eight minute spines; a similar group of minute spines occurs near the end of the middle abdominal legs.

For the colors the reader is referred to the description and figure by Riley, of the living animal, in the *American Entomologist*, i, 230. We have not yet seen a full-grown living larva. The foregoing description has been drawn up from four well-preserved alcoholic specimens.

This larva differs generically from Eacles in having well-developed dorsal spines on the prothoracic segment; while the lateral ones along the abdominal region are also well developed, these being nearly obsolete in Eacles. The genus Citheronia is unique in having seven spines on the eighth and the ninth abdominal segments respectively. All these characters are seen to be secondary and adaptive, and yet they are good generic characters, showing that the acquirement or loss of generic characters is due to adaptations to the surroundings. The specific characters are well brought out by comparing *C. regalis* and *C. sepulcralis*.

RECAPITULATION OF THE SALIENT FEATURES IN THE ONTOGENY OF CITHERONIA.

A. *Congenital Characters of the Larva, as seen in Stage I.*

1. The three pairs of enormous spines; the first or prothoracic pair but little shorter than the third, and the middle pair about two-thirds as long as the body, all ending in a swollen, triangular, two-horned flattened bulb; these appendages being deterrent and for offensive use in the earliest as well as latest larval life.
2. Both the eighth and ninth abdominal segments bearing a high median dorsal horn; and these segments bearing seven, instead of only five, spines.
3. The lateral spines on the abdominal segments nearly as large as the dorsal ones.
4. Body dark; head dark in color.

B. *Evolution of Later Adaptational Characters.*

1. The bulbous tips of the thoracic horns dropped at the end of Stage II (?).
2. The thoracic horns become curved in Stage II or III (?).
3. The thoracic dorsal spines become much stouter, with much shorter and stouter spinules at the last molt.
4. The mature larval features mostly assumed in Stage III.
5. The dark colors exchanged after the last molt for pale green, with bluish tints.
6. The black dorsal thoracic spots and the lateral yellowish bands most showy in the last stage.

Attention should be drawn to the colossal size of this larva, as compared with that of Sphingicampa and even Eacles, though the head is not so

much larger. This is due, perhaps, to its sluggish life, greater digestive and assimilative powers, so that a rapid acceleration of the growth of the body takes place; owing to its protection from the attacks of birds it may feed openly and continuously. It is thus like Sphingid and Attacine larvæ in its huge body and enormous appetite. The largest Cochliopod larvæ are the spiny ones, and the spiny or tuberculated Saturnians and Attacinæ have thick, large bodies.

FAMILY HEMILEUCIDÆ.

Notes on the Early Stages of Hyperchiria io (Fabr.).

At Brunswick, Me., the eggs were laid in confinement, June 5–7, and the larvæ hatched June 25, or about three weeks afterwards. Another year, larvæ in the second stage were observed July 16. For an excellent but brief description of all the stages see Riley's *Fifth Rep. Ins. Missouri*, 135; also Lintner's *Entomological Contributions*, ii, 146. Both authors state that there are six stages.

Egg.—Length, 1.8 mm.; width, 1.4 mm. It is regularly oval-cylindrical in form and slightly flattened; yellow during early embryonic life, with sometimes an orange spot on each side. Under a high-power triplet the surface of the shell is seen to be very finely granulated (not smooth and shining), and under a one-half-inch objective the surface is seen to be divided into close-set, very small, slightly raised but flattened areas, separated by narrow valleys; the areas are very irregular, but often are somewhat polygonal in outline.

Larva, Stage I.—Length, 5.5, when freshly hatched; the head, 0.8 mm. in width. The body is uniformly yellowish brown; the head and spines are dark, blackish brown. All the feet, both thoracic and abdominal, are of the same color as the body. The spines are in four rows, *i. e.*, there are eight on each segment, except on those bearing the abdominal legs, when the smallest or infraspiracular ones are wanting. The eversible glands are well developed; a pair on the first and a second pair on the seventh abdominal segment; they are situated behind the spiracle of their segment and between the subdorsal and spiracular row of spines. The spiracles are very small and hard to detect in this stage. The subdorsal spines are about as long as the body is thick, the dorsal ones a little thicker and longer; they end in usually fine setæ, one of which is finely barbed about as long as the spine itself. Both the subdorsal and dorsal spines of the three thoracic and of the eighth and ninth abdominal segments are deeply forked, the forks of equal length and each bearing the long bristle as well as four or five short ones. Those of the other segments are not forked. The first thoracic dorsal and subdorsal spines are as long and large as those on the two hinder segments. The spines are represented in Fig. 6.

Fig. 6 represents the freshly hatched larva, drawn with the camera, with the lateral, eversible glands (*g*).

Fig. 7 represents the armature of the three thoracic segments. *Pp*, the prothoracic shield; I, II, III, the bifid dorsal spines of the three thoracic segments, about three-fourths or four-fifths as long as the segments are thick; *sd'*, *sd''*, *sd'''*, the bifid subdorsal spines; *s'*, *s''*, *s'''*, the spiracular spines; the prothoracic ones throw off a bristle near the middle; in those behind this bristle is wanting; they are inserted just in front of the spiracle, the corresponding ones, however, on the abdominal segments being situated just below the spiracles; *i'*, *i''*, *i'''*, the small infraspiracular spines which are about half as long as the spiracular ones; *l'*, *l''*, *l'''*, insertion of the thoracic legs.

Fig. 8 represents the armature of some of the other segments. A, the third thoracic and the first and second abdominal; III, I', II'', the dorsal spines; and the other lettering as before; *sp*, the spiracle; *g*, the lateral eversible gland of the first abdominal segment. B, the sixth to tenth (and last) abdominal segments; faint traces of the spiracular and infraspiracular yellowish lines are to be seen, hence the medio-dorsal, the subdorsal, and the two lateral longitudinal lines of the larva in its second stage are already indicated in the first stage. The abdominal legs each bear eight ungues, or four on each side; and all except the anal legs bear a piliferous wart just above the planta; *sp*, the rugose suranal plate, bearing five piliferous warts on each side; *lp*, the lateral plate of the anal legs, with three or four piliferous warts.

Stage II.—Length, 7 mm.; width of head, 1.3 mm. The head is chestnut-brown. The body is uniformly reddish amber-brown; the spines are blackish brown, with the spines black at the tip. *The dorsal and subdorsal spines are now approximate in shape to those of the last stage, being bulbous at base, and with radiating stout spinules, but the latter are less in number than in the fifth and sixth stages.* The dorsal spines of the prothoracic segments are bifid, the forks of the same length, and each bearing a long hair; along the trunk are pale scattered tubercles, each ending in a long hair. The second thoracic dorsal spines have but one terminal piliferous spinule and a single lateral one, the other spinules ending in a sharp black point. The third thoracic is like all the abdominal dorsal spines which bear radiating spinules, not ending in a single piliferous spinule, as in Fig. 9, *vi*.

Fig 9, *sd'''*, represents a spine of the subdorsal series, the one figured being that on one side of the third thoracic segment, but those on the abdominal segments (except x) are like it, though most of the abdominal ones have two or three small tubercles near the base which bear barbed bristles, as at *sdvi*. All the long setæ bear a few minute barbs.

In Stage IV (?), when the larva is 20 mm. in length, the prothoracic dorsal spines are nearly twice as long as the second thoracic; the latter, however, have more spines at the base than those in front, and the lateral terminal are a little shorter than those on the first thoracic segment. The two dorsal spines on the third thoracic segment are, in size and spinulation, now exactly like those on the abdominal segments 1–9. The

median double one on the eighth abdominal segment is thicker than the single ones in front, also higher, and ends in two spines; the lateral spines are much more numerous than those in front. The spines of the subdorsal series are alike on both the thoracic and abdominal segments.

Last Stage.—The shape of the dorsal spines of the larva in its final stage is represented by Fig. 10. I, a prothoracic dorsal spine, ending in two equal terminal piliferous spinules, with seven or eight just below it, while at and near the base are the long, pale spines, each ending in a sharp black point; II, one of the second thoracic dorsal spines, the base short, bulbous, with very numerous radiating spines, and a single terminal, central piliferous spine, with a smaller one near it; III, a bush-like dorsal spine of the third thoracic segment, no piliferous spinules present. The abdominal dorsal spines are all on the same type.* The median spine on the eighth abdominal segment is about twice the size of the other dorsal single ones in front, though no higher, and it spreads more, having about twice as many spines on the sides. On the ninth segment are two dorsal and two subdorsal ones, and behind these four on the same segment is a median one. *These types are already attained in Stage II, though the spinules are fewer in number.*

It is to be noticed that the characters of the full-fed larva appear in large part in Stage II, and are almost fully developed in Stage III.

Fig. 11 represents the spiracle and lateral eversible gland of the full-fed larva; *g*, the eversible gland; *sp*, spiracle; *g'*, an eversible gland, enlarged.

In the large dark (in alcohol) larva of Hyperchiria, or perhaps of a Gamelia, referred to by me in *Proc. Bost. Soc. Nat. Hist.*, xxv, 91, the dorsal spines of the three thoracic segments are represented by Fig. 12. I, a prothoracic; II, one from the second thoracic; III, one from the third thoracic; VII, one from the seventh abdominal segment. It will be seen that the spines of this species are rather more generalized than in the mature *H. io*, and approximate those of the second stage of that species; the dorsal spine of the third thoracic segment ending in three piliferous spinules, there being no piliferous spinules at all in the homologous spines of *H. io*; the abdominal spines also (VII) ending in three piliferous spinules, though the other spinules are much (about one-half) less numerous.

Intermediate between those of *H. io* and the Mexican species is the *Hemileuca artemis*, from Las Cruces, New Mexico (Fig. 13), in which the prothoracic dorsal spine is like the Mexican form, the second thoracic dorsal spine like the prothoracic ones of *H. io*, and the third thoracic dorsal tuft like the second dorsal one of *Hemileuca yavapai* from Arizona (Fig. 14). In this last species the dorsal tufts of the body, as a whole, are intermediate between *H. maia* and *H. io*, but as regards the second and third dorsal and the dorsal abdominal ones, it approaches much

*The spines have been somewhat flattened in the animalcule box, but have been drawn with the camera.

nearer to *H. io*, as will be seen by an examination of the figures, the second and third thoracic spines being alike in shape. Hence the most generalized or primitive form, as regards its larval armature, appears to be the genus Hemileuca, and *H. maia* is the most like the young larva of *Hyperchiria io;* then succeeds the Cordova larva, then the New Mexican larva, while *Hemileuca yavapai* is more modified, *Hyperchiria io* being the most so of any under consideration and this may have been the last to be evolved.

The Young Larva of Hyperchiria io var. Lilith (Strecker).

About a dozen living specimens of these interesting caterpillars were kindly presented to me by Mrs. Annie Trumbull Slosson, who had collected them at Punta Gorda, Fla., where they were found in March feeding on the mangrove. They were described April 6. Mrs. Slosson considered them as belonging to Strecker's var. Lilith.

Length, 20–25 mm. The body is yellowish green all over. The lateral broad, reddish, spiracular band is as in northern specimens of *H. io;* it is broadly and distinctly bordered below with white. The head and all the legs, both thoracic and abdominal, are straw-yellow. The spines in general are bright, straw-yellow, more yellow than the body; the ends of the dorsal ones on the prothoracic segment are black, while the ends of the long spinules in general are more or less black, some merely tipped with black.

This is apparently a case of acceleration of development, as *the larva in its second (or third) stage resembles in coloration the full-grown northern form of the larva of H. io*, the markings, including the lateral reddish and white spiracular line, being as in the full-fed normal larva of *H. io*, and the general color of the body and spines being yellow, instead of gray and reddish, as in the normal *H. io* in its second and third stages.

Notes on Hemileuca maia (Drury).

Stage I compared with that of H. io.—In this stage *maia* is very similar to *io;* only the bifid dorsal tubercles or spines have shorter branches, the spines themselves being a little shorter, while the longest bristle is longer, the other bristles arising from the end of the spines being fewer, indeed only one, instead of three or four, as in the abdominal segments of *io*. The medio-dorsal spines on the eighth and ninth abdominal segments are much shorter and with a shorter fork, but with as long or slightly longer bristles arising from the forks. The larvæ of the two forms are of the same size.

Stage II (or III?).—*Maia* in what appears to be the second stage differs from *H. io* in its second stage in having much longer dorsal spines, with very much longer spinules. *Thus the generic characters appear in the second stage, as in H. io.*

The Larva of Hemileuca artemis sp. nov.*

Several full-grown larvæ were received from Las Cruces, New Mexico, kindly sent me June 15, 1891, by Mr. C. H. Tyler Townsend; they were found feeding on a species of long-leaved willow, and on a populus. Mr. Townsend writes regarding these caterpillars:

"I am informed that in previous years this caterpillar has been extremely abundant here, almost denuding the cottonwoods (*P. fremontei*). They are said to appear in force later in the season. I rather doubt this, but will look out for more."

Mature Larva.—Length, 45 mm. The body is long and thick, of the general shape and thickness of *H. io*, rather than of *H. maia*. Head dull shining red, about half as wide as the body in the middle. Segments of the body each with an irregular, deeply impressed, transverse wrinkle, just behind the middle. A moderately large prothoracic plate, which is irregular in shape and divided in the middle into two pieces; it is dull reddish honey-yellow or chitinous in color. On the prothoracic segment are eight large, high-branched spines, as large as any of the others on the body behind; they are black, with the spinules black at base, pale flesh color beyond; the terminal bristles are dark; there are about 16–18 spinules on each spine, nearly as in *H. maia*, and the prothoracic spines of *H. io*. The spines on the second thoracic segment are similar in shape and length to those in front, but slightly shorter and with a smaller number of spinules towards the end. On the third thoracic, to and including the seventh abdominal segment, the two rows of dorsal spines are like those of *H. io* behind the prothoracic segment, being short, thick, bushy spines, with numerous radiating, yellow spinules, which are black at tip. On the eighth segment there is a single, slightly larger one, with two central spines, one on each side. Those on the ninth segment are like the prothoracic ones, the median one being of the same size as the lateral ones. There are no spines on the tenth or last segment. There is a subdorsal and an infraspiracular row of spines like those on the first thoracic segment along the sides of the abdomen, but on the thoracic segments are two rows of infraspiracular spines. There is a rather large, broad, V-shaped or short subcordate plate on the tenth segment of the same color

* *Hemileuca artemis* sp. nov. 1 ♀ with wings not fully expanded. At first doubtfully referred to *H. juno*, I find on comparison with my types in the Museum of Comp. Zoölogy at Cambridge that it is quite different. The head and body are larger. The thorax is much more white, both on the prothorax and on the patagia, which are entirely white. The disk of the mesothorax is brown; the two tufts, one on each side behind, are orange-red, instead of claret-red as in *juno*, and the hairs between the forelegs and those on the fore femora are of the same deep orange-red as the thoracic tufts. *Juno* has more reddish hairs on the end of the abdomen, where they are all white in *artemis*. The fore wings are white, with a black-brown border all around, completely enclosing the entirely opaque black-brown discal spot, which, in the unexpanded specimen, does not enclose (as it does in *juno*) a lunate white spot. The blackish costal edge is as wide as the outer edge. The hind wings are apparently much as in *juno* and in *grotei*. It does not agree with the description of *grotei* (*Trans. Amer. Ent. Soc.*, ii, 192, Pl. ii, Fig. 60, 1868).

as the prothoracic plate, and a bristly, concolorous plate on the outside of the anal legs.

The body is smooth, without the granulations of *H. maia* and without the lateral reddish band of *H. io*. The body is pale, sea-greenish, with irregular brown spots and slashes in the spaces between the spines of the subdorsal rows, and they also occur lower down near the spiracles, which are yellow, edged with dark brown. Thoracic legs dark honey-yellow; abdominal ones washed with cherry reddish.

The eversible glands were not everted in any of the six specimens, but their position is indicated, as in *H. maia*, by an irregular oval, liver-colored patch behind the first thoracic and eighth abdominal spiracles.

Fig. 13 represents the dorsal spines of the three thoracic segments respectively. I, one of the dorsal prothoracic spines, in which the spinules, with long setæ, are scattered along the whole length of the main trunk; II, one of the dorsal spines of the second thoracic segment, surrounded at the base by a dense thicket of acute spinules, the latter not bearing a terminal seta; III, a dorsal spine from the third thoracic segment, forming a short, broad tuft or clump of non-setiferous, but acute spinules, the clump having a broad base, from near the centre of which arises a long spinule, bearing a slender seta, like those near and at the ends of those in front. The two dorsal rows of abdominal spines extend back to and including the seventh uromere.

FAMILY LASIOCAMPIDÆ.

On the Flattened and Scale-like Hairs of the Lasiocampidæ.—Dr. T. W. Harris* describes an Acronycta larva, *A. americana*, as "beset with a few long black bristles dilated at the end," and again says, "the long, black, spear-headed hairs grow from the skin and not from warts." A year or more ago, in examining the median dorsal tufts on the second and third thoracic somites of the European *Gastropacha quercifolia*, I found that they were composed of broad lanceolate oval scales, which were opaque and dark steel purple in color, with the surface quite regularly striated, though not invariably so. The striæ do not appear to extend to either end. They vary in shape and in size, some being narrow and with a simple point at the distal end, while the majority are variously notched or toothed, as shown in Fig. 15. They thus appear to be true scales, like those on the wings of Lepidoptera, etc.

In the same species the lateral tufts along the body contain each a few long hairs with flattened ends, the latter varying in shape from oval to triangular, with the ends often very broad and ragged, with from one to four very irregular teeth. No striæ are perceptible, and the hairs throughout are pale, colorless and transparent (Fig. 16).

* *Entomological Correspondence of T. W. Harris*, edited by S. H. Scudder, Boston, 1862, Pl. iii, Fig. 2. The same larva has also been figured in my *Guide to the Study of Insects*, Fig. 236.

Fig. 15.—Scales from the dorsal thoracic tufts of *Gastropacha quercifolia.*

Fig. 16.—Hairs with flattened ends, all from a single lateral tuft. *a*, a hair ending in two slender points, the only one seen.

On examining the lateral tufts of *Gastropacha americana*, I found some very long similar hairs flattened at the end and of extraordinary form, usually projecting beyond the simple hairs; some ending in regular lanceolate-oval shapes, with the point much attenuated, others broader, while some are oval and broad at the end, which terminates in a fine attenuated point, with usually three minute teeth at the base. They are similar in shape to those of *Gastropacha quercifolia.*

On turning over the beautiful plates of Burmeister's Atlas of the Lepidoptera of the Argentine Republic, I found that the author represents on Pl. xxii, Fig. 9, similar long hairs, much flattened and expanded at the ends, with 3, 4 or 5 long slender teeth, in the larva of his *Clisiocampa proxima*,* which, however, seems to differ from Clisiocampa proper. The hairs are visible to the naked eye, and are much more regular than any I have seen, and are also striated, with beads or clear spots.

In *G. americana*, the scales forming the dorsal tufts both on the two hinder thoracic segments and on the eighth abdominal one are very different from those of the European species; they are dark and opaque, but are long, narrow, flattened, very gradually increasing in width to the end, which has a single notch, and from the single notch an impressed line or stria extends along the middle for some distance.

Fig. 17.—Scales from the tuft on the dorsal tubercle of the eighth abdominal segment. *a*, the setæ × ½ in. obj.; *b*, *c*, similar ones × ⅓ A eyepiece.

Fig. 18.—Flattened hairs from the lateral tufts of the second and third thoracic segments of *G. americana*, color pale brown.

These flattened hairs seem common to the family of Lasiocampidæ, and should be looked for in the European species of this group. In *Heteropacha rileyana* there are no dorsal scales, but some of those in the lateral tufts have flattened ends, which are very long and slender, lanceolate-oval, with the tip much attenuated.

Fig. 19.—Flattened hairs from the lateral tufts of the second thoracic segment of *H. rileyana.*

I have been unable to discover these singular scales and flattened hairs in *Clisiocampa americana*,† or *C. neustria* of Europe, or in any other family

* Burmeister (p. 52) remarks: "Stoll has figured (Suppl. de Cramer, Pl. xix, Fig. 5) a similar larva with the same hairs, *à palmette terminale*, situated on the first and last rings of the body." He names it *Bombyx ephonia* (Pl. xxxv, Fig. 6, of the same volume). Walker refers this species with doubt to the genus Oxytenis. Burmeister adds: "Some other species of the genus Clisiocampa have the same hairs placed at the two ends of the body."

† In *C. sylvatica* the hairs on the lateral thoracic tubercles are tapering and finely barbed, with scattered slender spikes like smooth simple setæ.

In *Tolype velleda* there are no such scales or hairs with flattened ends as in Gastropacha, those on the dorsal tubercles of the thoracic and eighth abdominal segments being simple, tapering, with large scattering spike-like dark opaque setæ, these latter being perhaps the homologues of the dark scales of Gastropacha.

of Lepidoptera, except in the hairy Noctuina or Noctuo-bombyces, or Bombycoidea, where the hairs with flattened ends probably occur in the more hairy and penciled species. In the larva of the common American *Acronycta hastulifera*, many of the barbed hairs forming the black pencils are flattened at the end and black, but not striated.

Fig. 20.—Flattened setæ of various shapes, usually pointed. *a*, a small one; *b*, its barbed base; *c*, portions of the white barbed hairs; *d*, one blunt and notched at the end; all × ⅛ in. obj., and from tuft on the third thoracic segment of *A. hastulifera*.

These specialized and highly differentiated setæ, so like the scales of adult Lepidoptera, appear to be of use in rendering the pencils and tufts more conspicuous and stiff. The shortest and broadest, striated, scale-like setæ occur on the low, broad, stout, dorsal median tubercles of Gastropacha; and, perhaps, add a repellant nature to these shiny dark metallic tufts. At all events the occurrence of such scales is an interesting example of the acceleration of development of the setæ in these larval forms, and it is not improbable that in the ancestors of the Lasiocampidæ they were characters acquired during the later stages of their larval lifetime.

Partial Life History of Clisiocampa thoracica (Stretch).

Specimens in the third (?) stage were mailed April 28 from California by Mr. L. E. Ricksecker, and received and described May 5. It was feeding on willow leaves, but will eat sparingly of the eastern wild cherry. It has the same habits as the eastern *C. sylvatica*, spinning a web and living in clusters.

Larva, Stage III (?).—Length, 10–12 mm. In this stage it closely resembles *C. sylvatica* when next to the last molt, both in the shape and color of the exclamation-point-like pale dorsal spots; in having on each side an ochre-brown subdorsal line, though it is more broken, and a distinct, broad, lateral line, which is edged above and below with black. Below this line, low down on the sides of the body, are two whitish, reddish-yellow, wavy, irregular thread-lines, the lower one a little more distinct and pale tawny. The upper of these two lines is present in *C. sylvatica* (but the lower one is not present in Bridgham's drawing). The space between these two lines is somewhat livid, with pale blue and black dots.

The head is pale blue, with fine black dots, which are thickest on each side of the median line, and in the middle of each side. The prothoracic segment is bluish, with a median black hair-line, with two converging, lateral, black patches in front, and two shorter ones behind. The hairs on the body are deep tawny, those on the sides, low down, mixed with gray hairs.

Stage IV (?).—Length, 20 mm. Molted about May 10, observed from May 11 to 16. The marks and spots, especially the blue ones, are much more distinct than before. The black dots on the head are arranged more regularly than before, forming a triangular area on the vertex and

including the median suture, while there are two areas on each side containing the black dots, the lower group situated behind the eyes. The yellowish-white dorsal, median, exclamation marks are on a black field. The broad, now very distinct sky-blue subdorsal line is irregularly edged with black and above and below with a distinct, ochreous, wavy line. The blue line is, on the second and third thoracic segment, interrupted by a conspicuous square black spot, and a similarly situated black dot in the middle of each segment appears on the lower edge of the blue band, being a local dilatation of the lower black edging of the blue band. The eighth abdominal segment is slightly humped, and on the side the subdorsal blue band ends in a squarish black spot. The two lower ochreous lateral lines are distinct, the lower one extending along the base of the legs. The hairs are now snuff-colored; those on the sides, low down, being mixed with whitish ones.

Stage IV (?).—May 18 it molted again, its length being 18–21 mm. It is now quite different from the former stages. The yellowish-white exclamation point is now less distinct, the dot often obsolete, and the mark is now ochreous and white in the centre. The previously black dorsal band enclosing the median series of exclamation marks is now partly filled with blue specks, and *contains traces of a much interrupted wavy, deep reddish ochreous line.* The lateral blue lines and sides of the body in general are scarcely different from the former stages, though the red thread lines are deeper in hue. The hairs above and on the sides are now rather denser and more decidedly snuff yellow (the short, red, wavy lines in the dorsal spaces are new to this stage).

Final Stages of Clisiocampa thoracica (Stretch).

Received living from Mr. Ricksecker, May 5, having been fed on willow. Length, 28–30 mm. This belongs to the same stage as that described May 18, in my notes, but the dot of the exclamation mark is less distinct, the markings are more distinct, and the larva is larger, and they feed better. The blue and snuff or deep ochreous wavy spots and short lines are more distinct. Of the very irregular blue spots there are three on a side of the dorsal space on each segment enclosed by the subdorsal, reddish, ochreous lines. The second or lateral line is now, instead of being reddish ochreous, decidedly yellowish ochreous. May 27, one has molted to the last (?) stage. This larva is interesting as passing through a *sylvatica* stage with its dorsal exclamation mark.

The following description is drawn up both from living specimens and blown ones loaned by Prof. Rivers and named *thoracica* by him.

Full-fed Larva.—Length, 45 mm. Head deep blue, with two series of fine black dots along the top, and another broader series along the sides; with a clear bluish space between. The prothoracic or cervical shield is more distinct than in any others of the California species which I have seen, as it is freer from hairs and marked with blue; it bears two black

dots in front and one on each side. There are four subdorsal, ochreous, rust-red, fine, wavy, irregular lines, which are broken at the sutures and enclose three still slighter and much less regular more broken dorsal lines. Near the front of each segment these three short dorsal lines more or less unite to form a conspicuous oval, dull ochreous-red spot, irregularly centred with a paler hue; the spots on the second and third thoracic segments being paler and running more into each other. The ground color of the body is dull bluish, with black specks. The dot of the dorsal ochreous exclamation mark is now nearly or quite obsolete, sometimes represented by a few scales or irregular dots, and the main mark is itself sometimes irregular and reduced in size. On each side, just behind each exclamation mark, is a conspicuous black dot, and another similar pair behind, making four conspicuous dots, the anterior two more distinct than the others.

There are two irregular, subdorsal, wavy, Scotch-snuff-colored thread-lines edged with black. The pale sky-blue field of the back of each segment is divided by the two black spots into three bluish patches on each side of the dorsal area. The sides of the body blue, speckled with black. A lateral pale snuff line above the spiracles edged with black, which gathers in the middle into a dot, which is situated above the spiracle. A faint, double, flesh-colored, infrastigmatal line, very irregular, sometimes sending streaks towards the black spiracles, the lower of the two lines forming elongated patches at the base of the legs, the two lines being more or less confluent on the thoracic segments. In some specimens there is only a short, broken, snuff-colored line at the base of the abdominal legs; and a snuff-yellow dot on each side of the first thoracic segment.

The body is less hairy perhaps than in any of the other species. There are a few long, dark, dorsal hairs, with an undergrowth of fine ochreous hairs, and on the sides of the body below the spiracles are lateral, whitish gray, rather dense hairs, directed downwards. The hairs are longest on the thoracic and eighth abdominal segment, the latter being well swollen or humped on the back.

The body beneath is livid bluish, with pale flesh-colored patches on the front of each abdominal leg, except the anal pair.

This species differs from *C. fragilis* or *C. californica* in the rather less hairy body, and the four subdorsal rust-red lines, enclosing the three dorsal, short, rusty, broken lines which in front of each segment form a distinct, short, oval, reddish spot; and also in the distinct bluish cervical shield.

Clisiocampa constricta (Stretch).

The following description was drawn up from blown specimens kindly loaned me by Prof. J. J. Rivers, of the University of California.

Full-fed Larva.—Length, 46–48 mm. Head mottled with dull blue and black spots, the spots not arranged in lines, as they are in *C. thoracica*. The body is rather more hairy than in the other Pacific coast species, and

there is no distinct cervical shield. There is a dorsal row of about twenty ochreous rust-red patches, very irregular in shape, connected by two short parallel wavy lines of the same color. Each spot is situated on a deep velvety black field, ending behind in two conspicuous large black dots. From each red patch arise numerous hairs, forming a wedge-shaped ochre-yellow tuft. The ground color of the body is deep blue, spotted and mottled with black. There is a lateral row, one to each segment, of black dots, irregularly surrounded by ochre-red. Just below is a row of conspicuous short, thick tufts of white hairs situated near the front edge of each segment. Below each black spiracle is an obscure flesh-colored diffuse patch enclosing a small black dot, while beneath is a long black patch. All the legs, both thoracic and abdominal, and the under side of the body are livid blackish. The few dorsal hairs (the ochreous ones excepted) are black, those on the thoracic segments being longer than the others, while the lateral and ventral hairs are grayish, with an intermixture of ochreous ones.

The larva of this species differs from all the others of the genus known to me by the large, conspicuous, ochreous-red, dorsal spots giving rise to the peculiar wedge-shaped ochreous tufts, and by the lateral row of short white tufts, while the body in general is much more hairy than in the other species. No eastern species approaches it in these characters.

Clisiocampa fragilis (Stretch) (?).

This larva, referred with some doubt to the above species, was received from Mr. J. J. Rivers, who collected it in the Sierra Nevada. The following description was made from a blown specimen:

Full-grown Larva.—Length, 42–44 mm. Head bluish, mottled with heavy coarse black spots, with a tendency in their arrangement similar to that in *C. thoracica*. The cervical shield is very indistinct. The body is pale blue, with black specks and very irregular fine ochreous-red lines, more or less broken and confluent on the first three or four segments. The species is at once distinguished by the dorsal row of long, narrow, whitish-blue, distinct spots, beginning with the second thoracic segment, each spot extending nearly the whole length of the segment. On each side of the same segments are two large, conspicuous, irregular spots of the same color, beneath which is a band made up of broken, irregular, ochre-red hair-lines. The spiracles are situated in a broad bluish band. Body beneath black, with pale flesh-reddish or ochreous patches between all the legs, both thoracic and abdominal. There is a black dot near the base of the four median pairs of abdominal legs. The hairs above are rather denser than in *C. thoracica*, and ochreous; those on the side are ochreous running into gray, those on the sides of the thoracic segments being whitish.

This larva is at once known by the conspicuous, long, dorsal, pale-blue, almost whitish-blue spots, flanked on each side by two large, distinct, irregular spots of the same hue, with the space between conspicuously

deep black. Also by the numerous close, broken, fine, dorsal, alternating black and ochreous lines.

Two specimens of the same larva were collected by myself in the middle of June at Virginia City, Montana. It has the same markings, but the blue patches on the side are not so distinct, as they merge into the blue of the side of the body. On this account the black spots between the two blue patches is more distinct. In one example, however, the lateral blue spots are present. The markings on the head and the irregular ochreous-red lines on the anterior part of the body are just the same in the Montana example.

Partial Life History of Clisiocampa disstria Hübner (sylvatica Harris).

Of this caterpillar about a dozen described below were found on an oak leaf at Providence, May 24.

Stage III (?).—Length, 10 mm. Head not so wide as the body, black. The shape of the body is as in *C. americana* of the same age. The lateral prothoracic and other thoracic piliferous warts as in *C. americana*, but the markings are already very distinct. The prothoracic shield much as in the other species. There are four large, conspicuous, lateral, black, raised spots, two on the second and two on the third thoracic segment. The body is blue above, with two contiguous, parallel, broken, black lines, each dorsal bordered externally by a broken, deep, straw-yellow line, which widens on the sutures. *These black lines are wide, and in most of the specimens so encroach on the blue band, on abdominal segments 1–7, as to break it up into a median row of more or less pear shaped blue spots, which are diagnostic of the species*; thus the specific characters appear in this stage. Two lateral, linear, white lines enclosing a broad, blue stripe, the latter edged with a fine, broken black line. Abdominal segments 8 and 9 dull, livid blue. The body beneath is pale, livid, whitish. The thoracic legs are black; the abdominal legs with a black spot on the outside near the end.

The body is not quite so densely hairy as in *C. americana*, but the hairs are of about the same color, being pale brown above and whitish on the sides of the body and beneath.

In these examples the row of dorsal spots are seen to originate from the breaking up of the median blue band, owing to the encroachment of the black border.

Life History of Clisiocampa californica (Pack.).

I owe to the kindness of Mr. Cockerell a mass of eggs received from West Cliff, Custer county, Colo, and which hatched at Providence, April 14–15.

Larva, Stage I.—Length, 3 mm. Head and body of nearly the same proportions as in *C. americana*, but decidedly thicker and stouter, though

no longer. The color of the head and body are the same, being dull black, the head somewhat polished. The hairs are white, uneven in length, and, as in *C. americana*, a few are yellowish gray. The piliferous warts are distinct and rough. There is on each side of the median line of the body a row of about seven small but distinct, transverse, snuff-yellow dorsal spots, beginning on the first abdominal and ending on the seventh segment, there being more to be seen on the thoracic segments; they almost form a transverse linear spot, but are interrupted on the median line, though often continuous on the hinder edge of the segment, yet sometimes they are separate and the spots are narrowly triangular, the apices pointing outward away from the median line of the body.

Stage (?).—Length, 25 mm. The distinctive marks of this stage is *the row of lateral, black, elongated spots, sometimes broken into two portions, and then resembling a short, thick exclamation mark.* There is a diffuse, irregular, double black-brown dorsal band, enclosing on each segment an irregular, elongated, pale blue dash, which is more or less spindle-shaped, and ending in a point before reaching each suture. The clear, pale-blue sides of the body are also speckled with fine black dots.

Also in the last (!) stage the short, irregular, sienna or deep ochreous brown lines in the dorsal black bands become obsolete.

It differs from the eastern *C. sylvatica* in the dorsal median spots being pale blue; in the obsolete, ochreous, lateral lines, and in the much larger, lateral dark spots, while the entire side of each segment is pale blue, not gray below.

C. californica is in a more advanced larval stage than *C. sylvatica*, and should stand above it, the lateral black line disappearing, being broken up into spots, and the dorsal ochre lines being obsolete. It is thus a more specialized form. The larvæ eat sparingly on willow and aspen, living until July 15.

I received a bunch of eggs from Mr. Ricksecker, of Santa Clara, California, April 7. Some of the larvæ hatched on the journey east; they seemed unable to eat their way out. I assisted one by removing the uneaten rim, and as it came out the hairs were still moist and lay along the back; several (those arising from one wart) stuck together before it was able to extend the end of the body and to walk away. In four or five minutes the end of the body became extended, and it began to walk. The head and body are dull black; the hairs grayish white; the ochreous dorsal markings not yet to be seen.

The larvæ described below were received from Miss Morton, June 4. Do not eat willow, but feed on oak.

Stage II.—Length 10 mm. (after first molt). The body and head are of the same shape and proportions as in *C. americana* and *sylvatica*, but with the dorsal piliferous warts more distinct; a pair of dorsal warts on each segment, making two distinct rows, between which are two parallel broken, irregular, snuff-yellow, thread lines, beginning on the third thoracic and ending on the seventh abdominal segment. The body is dull

livid blackish, with a dull bluish tint. The sutures are smooth and shining; hairs reddish brown. The eighth segment is scarcely humped.

The duration of this stage was about 6–10 days, as it molted the second time June 10–14.

Stage III.—Length 14–15 mm. (after second molt). *The body is now distinctly deep blue and black;* the two yellow-brown dorsal lines are still more broken up. *On the side of each segment the blue contains a distinct longitudinal, somewhat pear-shaped black spot,* preceded in front by a black dot, like a short, thick exclamation point. The hairs are distinctly snuff-brown. *A dorsal median row of blue linear stripes, separated by the sutures.*

Remarks on Clisiocampa californica.—In two alcoholic, full-grown larvæ, length 36–38 mm., which I collected near Virginia City, Montana, the distinguishing marks are the two irregular, wavy, parallel dorsal fine tawny red lines, which, in my alcoholic specimens, enclose a faint blue median stripe, one on each segment, so that I think my Montana "(?) *fragilis*" is only a variety of *C. californica.* (In the third stage, Mr. Bridgham's figure of the Coloradian specimens, the median blue stripe is very distinct, becoming fainter in the fourth stage.) The parallel, tawny, reddish lines are very irregular, sending off short twigs and branches, and on the hinder edge of each segment there are short, broken, irregular, subdorsal, tawny-red lines. The body is unusually hairy, the dorsal hairs being tawny reddish. The body beneath is mottled and irregularly streaked with blackish and paler lines and marks.

In Stretch's "(?) *fragilis*" the two blue spots on each side, and in my specimens, are merged into the blue of the side of the body, but in another example they are distinct, and in the alcoholic Montana examples they are wanting. I am, therefore, inclined to think that "(?) *fragilis*" is only a variety of *californica.*

In one alcoholic specimen from Montana, the two blue spots on the side are just as in "(?) *fragilis.*"

Notes on Variation and on a Variety of Clisiocampa californica.

The Californian species of Clisiocampa seem to vary more in the larval state than our two eastern species, probably on account of the greater variety of climate, especially *C. californica,* which occurs in Montana, Colorado, Southern Nevada, and in the lowlands of California, thus extending over a vast region whose physical geography is very much varied, while it has different food plants. It is not improbable that *C. constricta,* in which the hairs and sides of the body are somewhat alike, has been derived from *C. californica.*

In a blown larva loaned by Prof. J. J. Rivers, the following remark is written on the label: "Supposed to differ from *C. californica.*" It is probably only a variety, and allied to a blown larva labeled by Mr. Rivers "(?) *fragilis,*" and kindly lent me by him. The hairs, ochreous

above and gray on the sides, are just as in *C. californica* and "(?) *fragilis*," but the dorsal pale-blue lines are nearly obsolete, being, however, present, though narrow, on the second and third thoracic segments, and on abdominal segments 4–7. The dorsal ochreous-red lines are present in front, but obsolete on the posterior half of the body.

It is characterized by a narrow, distinct blue streak on the side of each abdominal segment, extending from the lateral pale-blue stripe up into the dark-brown subdorsal region. There is a minute blue dot in front of the much more distinct streak, and these two spots are the remnants of the two normal lateral pale-blue dots of *C. californica* and "(?) *fragilis*."

Larva of a Clisiocampa not californica.

Received from Santa Rosa, Cal., from E. L. Ricksecker, April 20. The cast skin of the head of a larva of the first stage was found in the box.

Stage II.—Length, 3–4 mm. Head large, considerably wider than the body, including the first thoracic segment; black. Body dark, with a distinct, firm subdorsal and two lateral pale, snuff-yellow lines, the upper lateral one being the more wavy and thread-like. The subdorsal lines send in yellowish points or dilations along the sutures. A dorsal row of dull blue elongated spots, that on the second thoracic segment larger and shorter and broader than the others. The blue spots are wanting at the end of the body, the one on the eighth abdominal segment not so distinct as the others in front. The dorsal hairs are long and unequal, snuff-yellow brown; those low down on the side being gray, and uniformly shorter than those on the back.

Life History of Clisiocampa americana (Harris).

From a mass of eggs found on the apple at Providence, and several of which hatched April 14, one was seen, April 15, to make its way out of the egg. The hairs, immediately after the shell is broken open, stand up as erect and stiff as a few hours later, not being soft, flabby and matted together as often seen in hairy or spiny larvæ, such as the Attacinæ.

A brood of larvæ in the second stage and 5 mm. long was noticed in the crotches of apple and wild cherry trees at Providence, April 26.

Larva, Stage I.—Described when from ten to twenty-four hours old. Length, 2–3 mm. Head moderately large, as wide as the second and third thoracic segments, shining black, with numerous long, uneven white hairs. The prothoracic segment is a little wider than the second and third and than the head, and the lateral piliferous tubercle projects so as to add to the appearance of the width of the segment. From this segment the body narrows very gradually backward to the end. The body is wholly dull black, clothed with white hairs which arise from minute but yet distinct rough warts. While the sutures are livid and the front edge of the prothoracic segment is also livid, I can see no traces of any other colored spots like those of *C. californica*.

Stage II.—Described May 13. Length, 4-5 mm. The body still decidedly tapers to the end, though now the head is no wider than the body, which is blackish, *with a blackish dorsal line not yet turned blue;* the sutures are brownish; the hairs long and rusty brownish. The piliferous prothoracic tubercles are now small and not conspicuous as they are in Stage III.

In some observed April 26 (length, 5 mm.), and belonging to an earlier brood, *the median dorsal black line was broken and on each side of each segment is a black blotch.* The dorsal hairs brownish, those on the side gray, and some of those on the back tawny.

In another set of larvæ, from the web on wild cherry, 5–6 mm. long, described May 5, and apparently at end of second stage, the head is not so wide as the body, and considerably narrower than the prothoracic segment. *There is no blue about the body.* The head and prothoracic segment are black. A distinct black dorsal line interrupted at the sutures. On each side is an obscure similar dark line, but more interrupted and the spaces between the sections longer; below each section on each segment is a large, conspicuous, black, longitudinal, irregular, oval spot, immediately below which is a wavy light line, and parallel to this is a similar light line, below which is a fringe of whitish hairs projecting from the body. The dorsal hairs are pale ash-gray, not distinctly tawny. Abdominal segments 8-10 black, without markings. Some of the larvæ are much paler than most of the lot examined.

Stage III.—Length, 7–8, becoming 9–10 mm. Described May 13. The body still tapers to the end. The lateral prothoracic tubercles are well marked, and there is a pair of small dorsal ones on each succeeding segment of the body, bearing the usually tawny hairs, those on the sides being white, with some black hairs. *A distinct blue dorsal stripe, beginning on the second thoracic segment and disappearing on the eighth abdominal segment;* it is of the same hue as in the full-fed larva, and bordered with a fine wrinkled white line. *There are two lateral white thread-lines,* the upper one the more distinct; towards the end of the stage these lines change to a blue. Between these two lines is a row of minute black warts. The larvæ when in this stage vary much in the distinctness of the dorsal median blue stripe. It molted May 20–22, the length of the stage being about seven days.

Stage IV.—Length, 13–14 mm. The blue line is as in the full-fed larva, *but the lateral, linear, upright blue lines, one on each side of each segment, have now appeared, and also the very irregular, short, thread-like blue and yellow lines on the top and sides of the body.* The lateral prothoracic tubercles are still pronounced. It molted June 5–6; the duration of the stage being about fourteen days. June 8, 9, 10, full-grown larvæ seen out of doors. June 14, they were spinning their cocoons. The season was two weeks late.

In specimens of this stage, 22 mm. in length (described May 24), the dorsal band is now continuous and firm, not broken, and pale blue. On

each side of the median line along the back are faint, thread-like, fine, short broken lines, only perceptible under a lens. Besides the continuous pale-blue dorsal line, the distinctive marks are the two darker blue spots, short and straight; the one in front longitudinal and at right angles to the other, which is transverse and more distinct because situated on a black field. The sides of the body are filled in with blue, containing some fine ochreous lines, especially on the upper edge of the blue area below the longitudinal blue mark. The ordinary spinulated hairs of *C. americana* are represented by Fig. 21.

A variety of the larva of Clisiocampa americana observed at Providence, June 5 and 6.—One full-grown larva has the white dorsal line twice as wide as usual, and broken up into a series of exclamation marks. The line is interrupted at the sutures and each stripe swells out at the posterior end into a knob, and on the sixth abdominal segment it is short, and succeeded by a large, round, white spot, while on the first abdominal segment the stripe is represented by two large round spots.

The Young Larva of Gastropacha americana.

Found on an apple tree at Brunswick, Me., July 28.

Stage III (?).—Length, 17 mm. The head is rather small, about three-fourths as wide as the body, rounded but flattened in front, blue slate-gray, nearly concolorous with the body. The prothoracic segment is much broader than the head, with a very large and prominent pale clay-yellow or luteous lateral tubercle on each side, bearing numerous long gray hairs. The second and third thoracic segments each with two dark, flattened, button-like warts centred with grayish. The sutures at hinder edge of second and third thoracic segments respectively are stained with pale ochre-yellow or luteous, forming a transverse stripe which is partly visible when the worm is at rest, but revealed more distinctly when it is in motion. On each segment behind first thoracic are four dorsal piliferous warts, two most conspicuous on second and third, and others on the side; those on the abdominal segments four in number and arranged in a square. From the first yellowish transverse dorsal streak is a longitudinal subdorsal concolorous (yellowish) line, and below it a concolorous fine hair-line between two dark lines. The body is dull, livid, bluish slate-gray, mottled and finely spotted with blackish points and piliferous warts. Along the side of the body the lateral tubercle, one on each side of second and third thoracic segments, is large, but not so long and slender as that on the segment in front, but yet they are unusually large and well developed, and they are replaced on the abdominal segments by the large fleshy lappets, bearing long, dense, fine, gray hairs, which are directed downwards. There are as yet no traces of the dorsal tuft of flattened hairs present in the mature larva. On the eighth abdominal segment is a decided rounded hump bearing two black flattened warts, from which arise numerous fine black hairs. The dorsal hairs are in general black,

and about one-third as long as the body is thick. The thoracic and abdominal legs are slate-gray, of the same color as the body.

Life History of Heteropacha rileyana (Harvey).

This caterpillar has been reared from the honey locust (*Gleditschia triacanthos*) by Mr. Pilate (Papilio, ii, 67), while Prof. G. H. French writes that he has also found it on that plant. In response to my request, Mr. W. N. Tallant, of Columbus, O., sent me early in August several young larvæ, at Brunswick, Me., where its food plant flourishes; and a year later he kindly sent me the eggs and larvæ of this interesting form. Regarding its habits he writes me as follows: "Eggs deposited May 15. We have two and probably three broods per year. Eggs generally laid in a cluster or in a row or rows of twenty to forty. In confinement they will be deposited on the leaves or branches, but in nature I think they are always deposited on the bark, at least I have never found them on the leaves." The eggs hatched during May 25 and 26, not all simultaneously, and the description was made from the freshly hatched individuals, those which had been out of the shell for about half a day not differing from one I saw creeping out of the egg.

Egg.—Length, 1.5 mm. Cylindrical, though but slightly longer than broad. The shell is of a peculiar bluish white, the surface not highly polished, and under a Tolles triplet (about 12–15 diameters) it is not seen to be pitted, but under a half-inch objective, small, faintly marked hexagonal areas can be seen which are quite irregular in shape and with a thickened or raised central area. The surface of the shell is of a peculiar porcelain texture and bluish white, with short, broad, curved, darker blue streaks.

Larva, Stage I.—Just hatched. Length, 3 mm. The head is large and about one-third wider than the middle of the body; it is broad, being a little wider in front of the middle than behind. It is of a pale horn color, with a broad dark median band extending from behind and ending at the apex of the clypeus, where it spreads out somewhat, stopping at the transverse pale band crossing the head, and which dilates at the end on each side of the head. On each side of the dark band is a parallel pale band which passes down to the middle of the front, and then curves outward at a right angle, dilating at the end.

The side of the head is blackish, or rather the white portion leaves a large, much curved black band. The head is clothed with long, rather thick blackish and gray hairs.

The body gradually tapers backwards from the broad prothoracic segment which flares outward and upward in front. The segment is pale horn color above, rather naked. On each side is a piliferous tubercle, which is slightly larger than those on the succeeding segments, but not so well developed and prominent as usual in the group; at first pale, it afterwards turns darker, and it bears mixed dark and gray hairs, more

numerous than those on the succeeding segments. A broad median dorsal band, enclosing a fine, narrow, more or less interrupted dorsal dark line. On top of the second and third thoracic segments is a broken transverse fine black line, and on the same situation on each of the first eight abdominal segments are four minute square black dots, sometimes coalescing to form two transverse lines. A broad lateral (almost subdorsal) black band, consisting of a dark rounded oval patch, on each segment enclosing a minute pale piliferous wart. Below this and on the under side the body is pale livid flesh color, including the thoracic and abdominal legs. The hairs in general are short, rather evenly and closely cropped, and the dorsal ones of quite uniform length, not so long as the body is thick and mostly black, while the lateral ones are gray and spread straight out as usual in the group, touching, or nearly so, the surface the larva rests on; they are much more unequal in length than the dorsal ones. The anal legs are large and long, rather slender, spreading wide apart.

Stage II.—Length, 9 mm. All molted June 1. The head is now scarcely wider than the body, which is now dull blackish brown. The markings are nearly as before, the two parallel whitish lines turning out at right angles opposite the apex of the clypeus, which is now white, and the front of the head beyond the eyes is whitish. The head is hairy, with dense gray hairs in front. The body still tapers towards the end, and is now dull black-brown striped with eight fine whitish lines; of these the two dorsal ones are very faint, while the single subdorsal line is distinct, and in one or two, a day after molting, already stained with reddish ochreous; below are two parallel lateral whitish lines, the lower of which is wrinkled. On the eighth and ninth abdominal segments the two subdorsal lines are broken up into two dots on each segment. All the legs, both thoracic and abdominal, are dark brown. Many of the short dorsal hairs are black, those on the sides of the body longer and gray, as before. The lateral prothoracic tubercles are well marked, a little larger than those behind. In this stage nearly all the characteristic markings and colors are assumed.

Stage III.—June 4, 5, 6, 7, different ones molting on each of these days. Length, 12 mm. Head brown, with the whitish markings more *distinct than before.* The markings (spots and lines) are *decidedly brighter and more conspicuous than before;* and the body behind the prothoracic segment is *rust red ochreous above.* Prothoracic segment dark brown, with two yellowish triangular dots or notches on the outside of the dark dorsal tubercles. Behind this segment the dorsal, median, ochreous, rust-reddish band is distinct. The two subdorsal lines enclosing or forming the band are fine and distinct *ochreous rust-reddish and yellow, and they include on each segment a pair of long, somewhat wavy black stripes,* which are connected on the second and third thoracic segments, but separated by the sutures on the abdominal segments, so that there is a pair to each of these segments. The sides of the body are dark leaden brown, with two distinct lateral lines, and sometimes the lower broken whitish line is wanting. The

essential markings of the full-fed larva are now assumed. The clypeus is dark in the centre, white on the apex and edges. The whitish gray hairs are conspicuous and nearly conceal the thoracic and abdominal legs. The two dorsal yellowish dots on abdominal segments 8 and 9 are now conspicuous. The larvæ feed more or less concealed under and among the leaves in the breeding box, and this habit persists throughout the larval life.

Stage IV.—June 15–16. Most of them had molted June 16.

Stage II (?). —Summer brood. Length, 4.5–5 mm. Described August 6. The head is moderately large, considerably wider than the body, which tapers gradually to the end. The head is densely covered with long slender pale hairs of the color of the head, which, like the body and legs, is a greenish yellow-brown or pale snuff color. It is not easily to be seen while resting on the green leaf stalk of its food plant. The head is broad, full and rounded, with a median longitudinal dark-brown band, ending in front in a darker spot; the head on each side is brown, sending a point forward towards the middle of the head, and a brown band along the side of the head to the ocelli, from which another brown band extends across in front to the side of the clypeus, which separates it from its fellow on the other side.

The piliferous warts are minute, low, bearing several short, fine hairs, so that the body is quite hirsute. The lateral prothoracic tubercles, instead of being, as usual in the Lasiocampians, large and prominent, are in this larva scarcely larger than the others on the body. There is a faint dorsal median brown line. There is a subdorsal row of thoracic and abdominal piliferous tubercles, darker than the others; also a broader, darker lateral row of spots, each surrounding a broad, flat, dark, piliferous wart, connecting with the lateral dark band on the head. Below this is a narrower, paler lateral spiracular line, enclosing the pale, inconspicuous spiracles. The anal legs are broad and large, spreading widely. Both the thoracic and abdominal legs are concolorous with the body, and are densely hairy.

In another larva, 7 mm. in length and better fed, with the body filled out, the head was no wider than the body, as in the other, but the bands and spots, especially the dorsal and subdorsal ones, were more distinct than before. The subdorsal tubercles are flattened and enclosed in large, oblong, dark, longitudinal spots. The spiracular line is broad and more distinct, and below it, directly above the base of the legs, is a series of dark gibbosities.

In a third larva of about the same age and size, the body is more reddish than in the others.

Stage III.—August 16–20, summer brood. Length, 17 mm. The head is narrower than the body, dull slate-brown, like the brown portions of the body. On each side of the vertex are two parallel, dull ochreous brown stripes, soon becoming distinctly yellow, and opposite the apex of the clypeus turning outward at right angles and following a

sinuous course, and ending on the side of the head. There is a V-shaped yellow patch on the clypeus, which also sends an obscure yellowish line outward, in a course parallel to the line above. The labrum is pale; the face very hairy, as is the whole head. The body is dull, dark manganese or iron-brown. There is a dorsal, obscure, median, irregular, reddish-brown line; *also two dull-yellow, narrow lines on each side of the body*, the upper one of the two being the subdorsal one, and more or less stained with reddish. *There is an obscure, broken, yellowish line along the base of the legs below the dark spiracles.* The prothoracic segment is slightly swollen on the sides. The dorsal hairs are short and fine, but along the lower part of the face, and along the side of each thoracic and abdominal segment, is a swelling from which arise dense, long, pale-gray hairs directed downwards, much as in Gastropacha. The thoracic and anal legs are dark livid, and the body beneath is livid. The surface of the skin in general is rough and rather dull in color.

Stage IV.—Molted August 25 and described a few hours after. In the larva of the previous stage the left (?) anal leg was injured and shorter than the other; this defect was retained after this and the last molt.

Length, at first, 17 mm. The head is now larger in proportion than before, being a little wider than the body; it is somewhat bluish brown, with the markings as before, but much more distinct; the two parallel lines on the vertex not so diffuse and reddish as before, but nearly black, and each enclosing a lanceolate-oval, distinct, fleshy, whitish spot of the same color as the two sets of transverse, sinuous lines below. The face below is pale carneous; and on the sides and in front more densely hairy than above.

The body is of the same shape as before, still tapering to the end. Along the body extends a dorsal, reddish-brown, diffuse line as before, but a new system of markings appears in this stage, consisting of *a set of four small light dots, two on each side of the dorsal median line.* The prothoracic shield is now very distinct and concolorous with the head, and the segment is slightly wider than those succeeding, while the lateral, prothoracic, piliferous warts are still small. The subdorsal stripe is concolorous with the single dorsal one, but the lateral and infraspiracular line at the base of the legs are now more yellow; otherwise the body in general is dark brown as before. On the end of the seventh and eighth abdominal segments are two pale-yellowish spots, and on the base of the suranal plates are two dark-yellow spots; the surface of the plate itself is concolorous with the prothoracic shield. All the legs are dark. The hairs low down along the side of the body are whitish gray, dense and depressed, partly concealing the legs, especially the middle abdominal ones.

Stage V and Last.—Molted September 4. Described September 12. Length, 32 mm. The head is as before. There is now visible, when the larva creeps, what had not been noticed in the preceding stages, *viz.*, *a*

bright, transverse, deep-orange, irregular band in the sutures between the second and third thoracic and the third thoracic and first abdominal segments. In the middle of each band is a black dot situated in the median line of the body. When the larva is at rest and the segments contracted, these two conspicuous stripes are not visible. They are evidently warning or danger signals, like the showy, bright band of *Gastropacha americana.*

The anterior corners of the prothoracic segment are dull orange-brown, the segment itself being dull dark-brown, with no lines. The median dorsal rather bright tawny-brown stripe begins most distinctly on the first abdominal segment, and extends uninterruptedly to the base of the suranal plate. The subdorsal lines, one on each side, are brighter ochreous orange, but are broken up, not only at the sutures, but by the transverse wrinkles, of which there are usually about five to each abdominal segment. The subdorsal lines or stripes are interrupted at the hinder end of each segment, next to the suture, by an irregular, squarish, light, tawny, ash patch, those on abdominal segments 7 and 8 being much paler and more distinct than the others in front.

The lateral supraspiracular line is narrower than the subdorsal stripe, less ochreous, with a little more pale yellow in it; it is irregular and broken, contains short, wavy, blackish lines and isolated dots, and dilates a little at the hinder end of each segment, forming a linear, light, pale, obscure yellowish spot opposite the light spots in the subdorsal stripe. Spiracles distinct, dull carneous, surrounded by a blackish-brown ring. An infraspiracular indistinct, wavy, narrow, tawny-yellowish, much-broken line, most distinct under the spiracles. Still below this obscure line the lateral ridge, which is quite broken, is marked with two obscure tawny-reddish, vertical slashes on each segment; one is single, and the other is slightly V-shaped, the apex pointing upwards. The suranal plate is ornamented in front by the end of the dorsal tawny or Scotch-snuff brown band, broadly edged with ochreous yellow, the rest of the plate being black-brown.

The anal legs are dark-brown, with no markings; the middle abdominal legs are spread out laterally a good deal, so as to show from above almost their whole length; the legs themselves are, at base, livid lilac-brown, the plantæ pale livid, with a black chitinous streak on each side; these peculiar black chitinous pieces are narrow triangular, with the slender very acute apex pointing upwards, and are distinctly visible from above. The dense hairs arise from the longitudinal folds of skin situated over the abdominal and thoracic legs and corresponding situations on the other segments.

The Young Larva of Artace rubripalpis (Feld). (A. punctistriga (Walk.).)

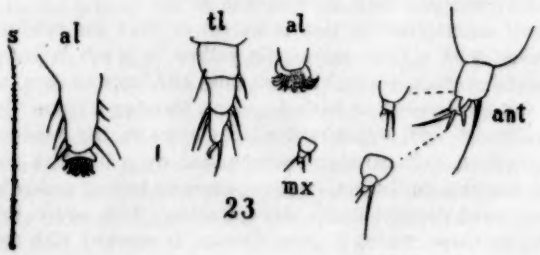
A batch of eggs was kindly sent me by Prof. Roland Thaxter, from Cullowhee, N. C., early in July, the larvæ hatching July 9. The larvæ

were fed with oak, maple, raspberry, willow, poplar, hazel, rose, sumach and fir leaves, but they did not eat them. On being taken up, the freshly hatched larvæ spun a thread by which they let themselves down.

Egg.—Round, with the surface granulated; of a dirty white, clouded with reddish brown. They are laid separately in an irregular bunch.

Larva directly after Hatching.—(Fig. 22.) Length, 3 mm. The head is large, as wide as the prothoracic segment, dark brown, with two transversely oval light-gray spots above; along the front edge of the epicranium is a broad gray stripe, and at the base of the labrum is a transverse less distinct pale band.

The prothoracic segment is very large, slightly wider than the head, and from this segment the body tapers to the end. On each side of the prothoracic segment, and projecting outwards, is a large piliferous amber-colored tubercle, which is three times as large as those behind it on the succeeding segments. Between these are two minute dorsal piliferous tubercles. On each side of the second and third thoracic segments is a



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lateral amber-colored piliferous tubercle, while the dorsal tubercles between are rather larger than the lateral ones. On the abdominal segments the dorsal tubercles are amber-colored, becoming dark on the terminal segments, while the lateral tubercles are dark, concolorous with the body. The hairs are gray and dusky, those on the large lateral tubercles the longest and curved forwards in front of the head. Behind these the longest hairs are a little longer than the body is thick. The body is dark. On the abdominal segments the dorsal tubercles are amber-colored, becoming dark on the terminal segments, while the lateral tubercles are dark, concolorous with the body. The hairs are gray and dusky, those on the large lateral tubercles the longest, and curved forward in front of the head. Behind these the longest hairs are a little longer than the body is thick. The abdominal legs are long and slender, spreading outward beyond the body. The eighth pair of dorsal abdominal tubercles are a little larger than the others.

In general appearance, viz., the large, broad, first thoracic segment, the body tapering backward from it, and the large prominent lateral piliferous warts, one on each side of the segment, this larva is a true Lasiocampid,

with its characters rather more exaggerated than in Clisiocampa, and perhaps much as in Gastropacha.

Some details of the freshly hatched larva are represented in Fig. 23. *ant*, antenna; *mx*, maxilla; *tl*, a thoracic leg; *al*, an abdominal leg, showing the planta and crotchets; *al'*, another leg; *s*, a spinulate seta. (Author del.)

Explanation of the Plates.

Plate V.

Fig. 1. *Dryocampa rubicunda.* Larva in Stage II. The line under the figure should be nearly one-half longer. Bridgham del.

2. *Sphingicampa bicolor.* Armature, Stage I. For explanation of details and of lettering, see the text.

Plate VI.

Fig. 3. *Eacles imperialis.* Armature, Stage I.

4. *Eacles imperialis.* Armature, later stages.

Plate VII.

Fig. 5. *Citheronia regalis.* Armature, Stage I.

6. *Hyperchiria io.* A freshly hatched larva, showing the eversible glands (*g*), etc.

7. *Hyperchiria io.* Armature of the three thoracic segments, Stage I.

Plate VIII.

Fig. 8. *Hyperchiria io.* Armature of the last thoracic and abdominal segments, 1, 2, 6–10, Stage I.

9. *Hyperchiria io.* Armature of the sixth abdominal segment, Stage II.

10. *Hyperchiria io.* Spinulated dorsal tubercles of each thoracic segment, final stage.

Plate IX.

Fig. 11. *Hyperchiria io.* Eversible gland, with the adjoining spiracle, *sp.*; *g'*, a gland enlarged.

12. *Hyperchiria*, sp. from Mexico. Armature of final stage; dorsal tubercle of each thoracic and of the seventh abdominal segment.

13. *Hemileuca artemis.* Spinulated dorsal tubercles of each thoracic segment, final stage.

PROC. AMER. PHILOS. SOC. XXXI. 141. Y. PRINTED MAY 11, 1893.

PLATE X.

Fig. 14. *Hemileuca yavapai.* Spinulated dorsal tubercles of each thoracic segment, final stage.

15. *Gastropacha quercifolia.* Scales from dorsal tuft on second thoracic segment of the mature larva.

16. *Gastropacha quercifolia.* Flattened hairs from the lateral tuft of the second thoracic segment of the larva.

17. *Gastropacha americana.* Flattened hairs from the lateral tuft on eighth abdominal segment of the mature larva.

PLATE XI.

Fig. 18. *Gastropacha americana.* Flattened hairs from the lateral tuft on second and third thoracic segments.

19. *Heteropacha rileyana.* Flattened hairs from the lateral tuft on the second thoracic segment of the mature larva.

20. *Acronycta hastulifera.* Flattened hairs.

21. *Clisiocampa americana.* Normal hairs, densely spinulated.

22. *Artace rubripalpis.* Freshly hatched larva. Bridgham del.

Note.—All the figures, except 1 and 22, were drawn by the author with the camera.

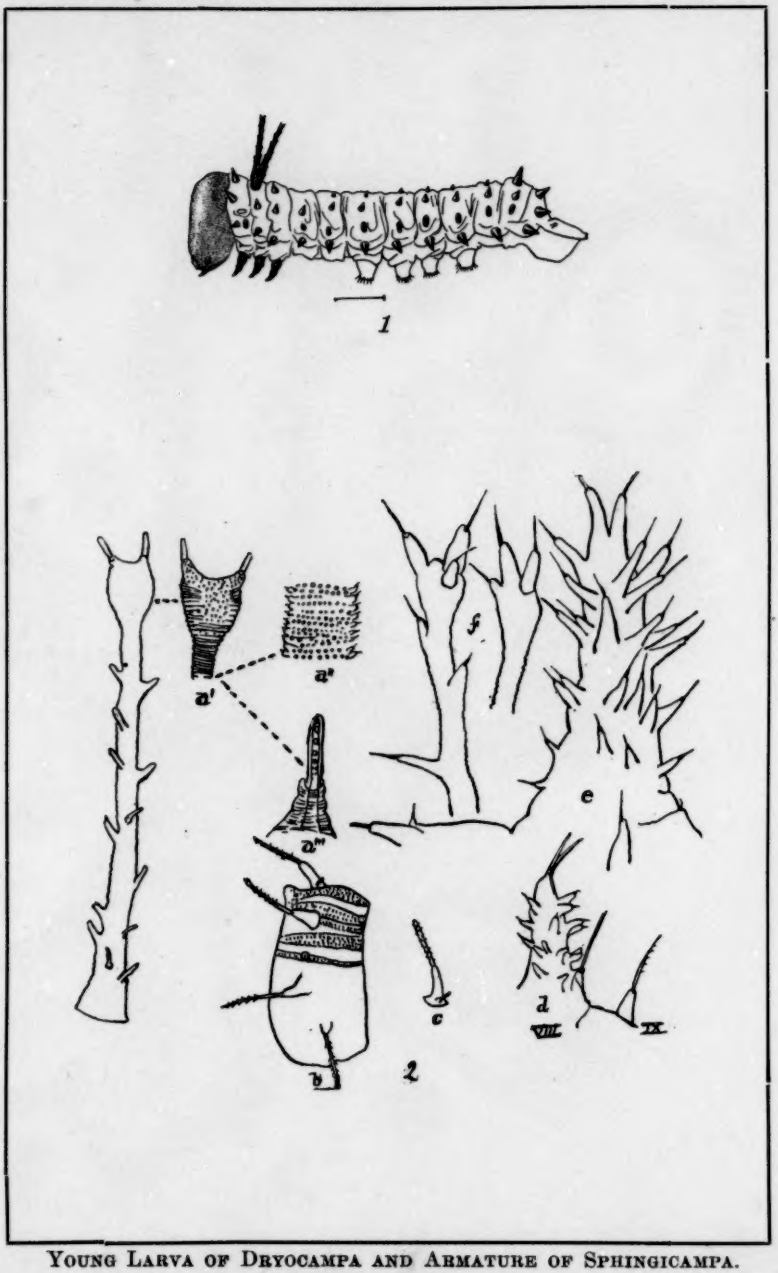
Energy as a Factor in Organic Evolution.

By John A. Ryder.

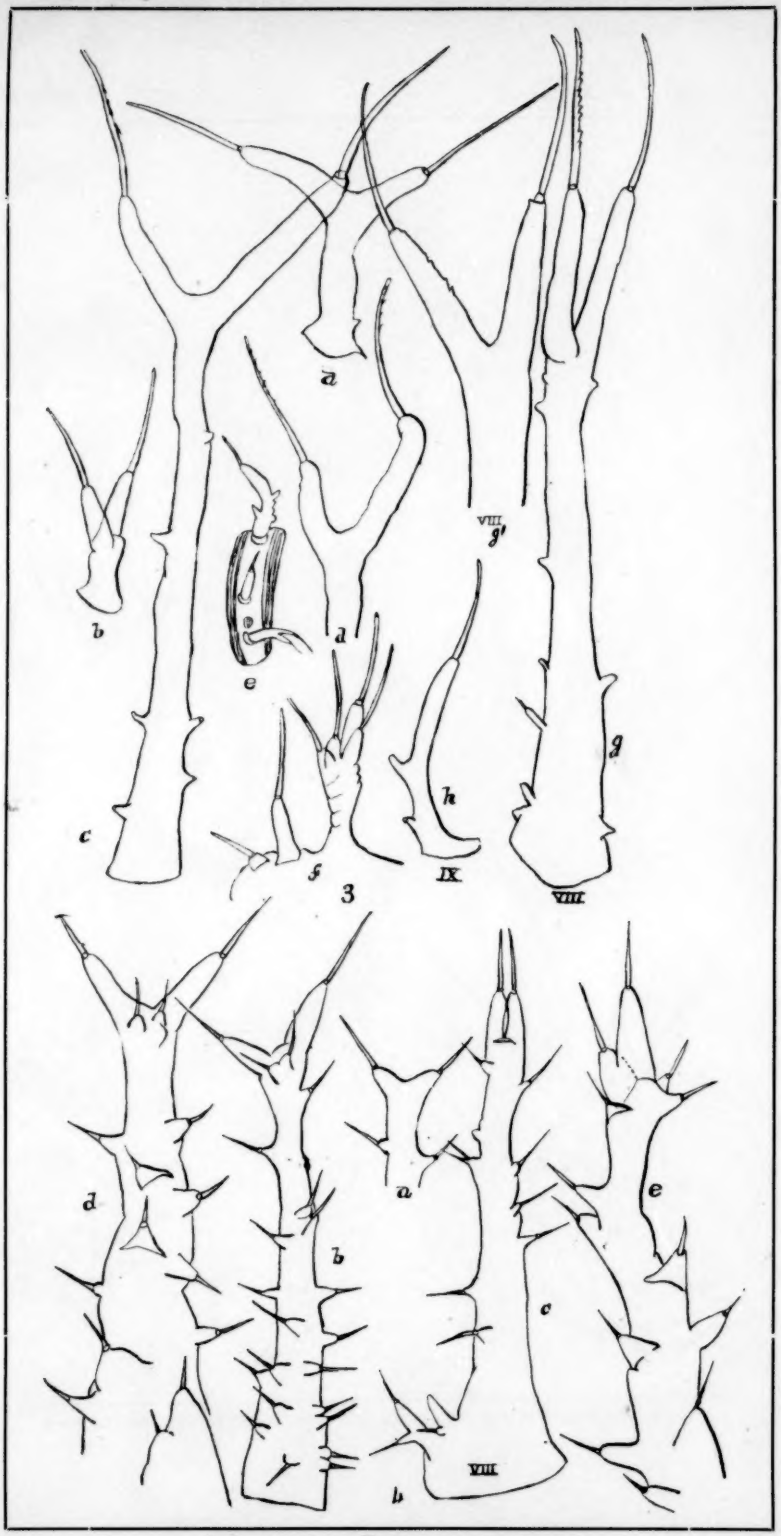
(*Read before the American Philosophical Society, April 7, 1893.*)

The fact that the energy developed by living bodies is correlated with cosmical energy is now a recognized canon of physiology. To give the proper emphasis to the part played by the energy developed within organisms, as a factor in the development of their own forms or *morphogeny*, is the purpose of the present paper. To define exactly the kinds of energy displayed and the mode in which its effects are produced in particular cases is another part of the subject to be dealt with. The definition of these subjects renders necessary the introduction of a few new terms, in order to avoid awkward circumlocution, to achieve brevity or directness of expression, and to eliminate the risk of indefiniteness in the use of words.

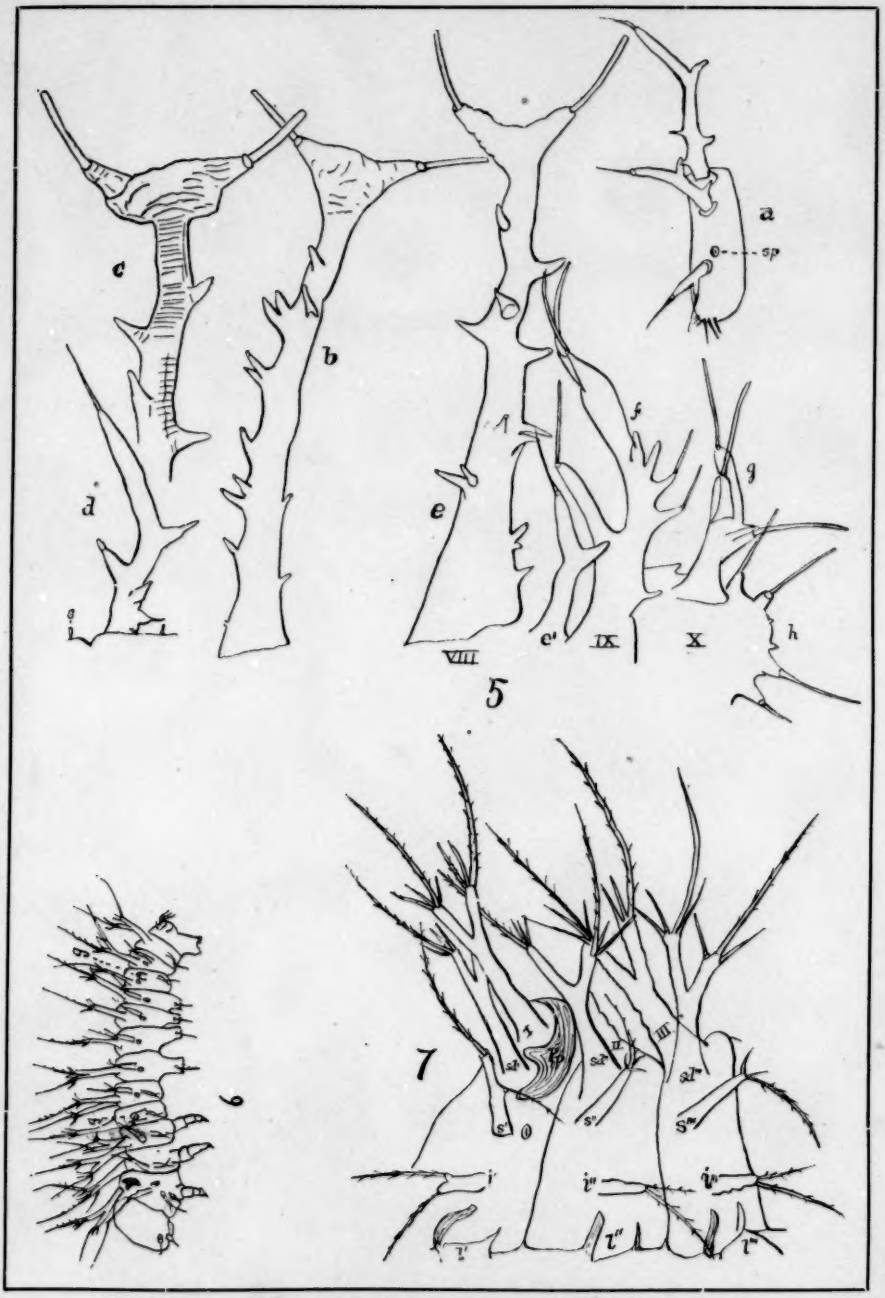
Hæckel very felicitously proposed the term *phylogeny* to express the fact that a certain tendency directed the drift or trend of development of a being along a line parallel with that of the series of forms ancestral to it. The being in the course of its development briefly recapitulated that of the ancestral series to which it belonged. This, in substance, is the famous fundamental *biogenetic law* first suggested by F. Müller.



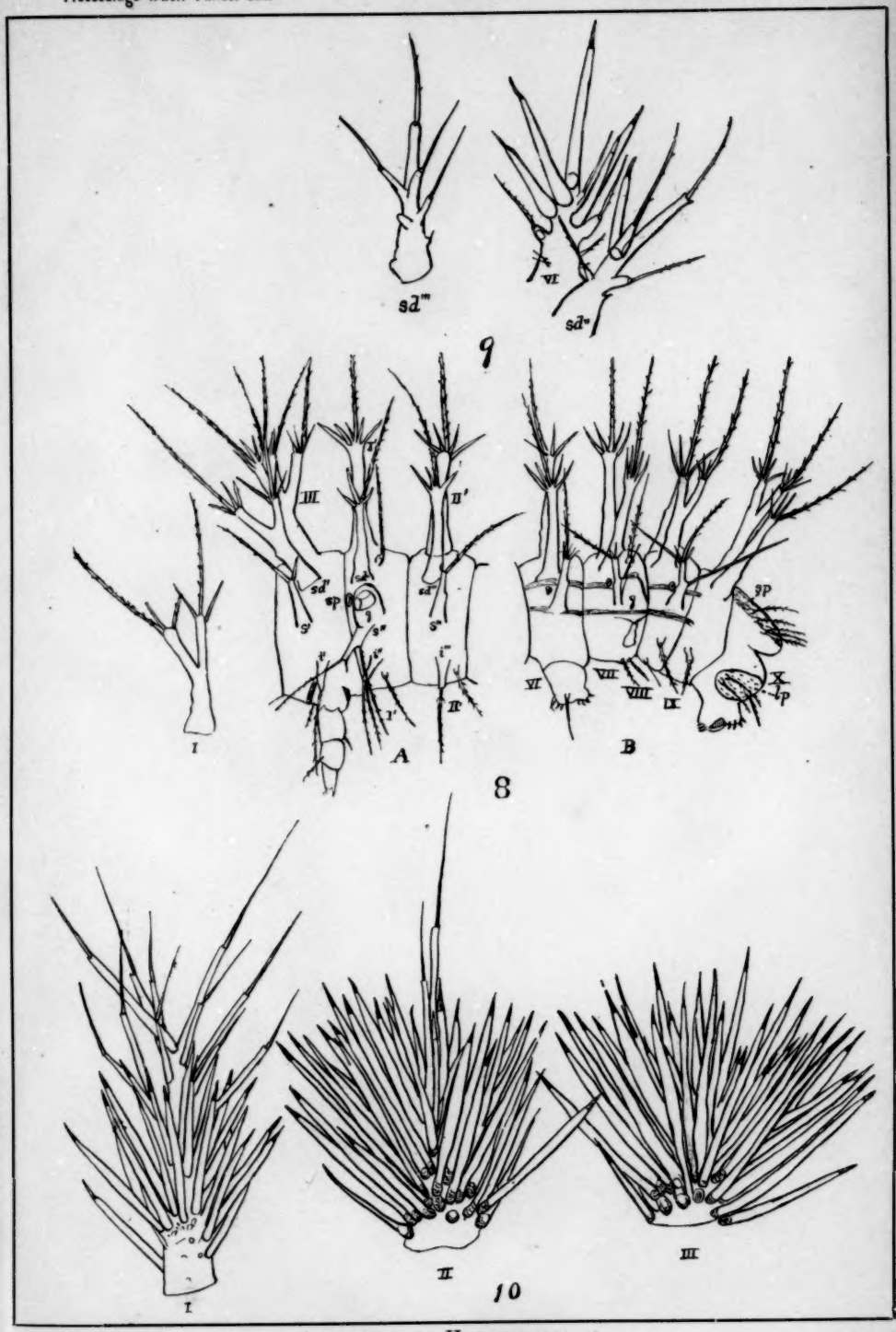
YOUNG LARVA OF DRYOCAMPA AND ARMATURE OF SPHINGICAMPA.



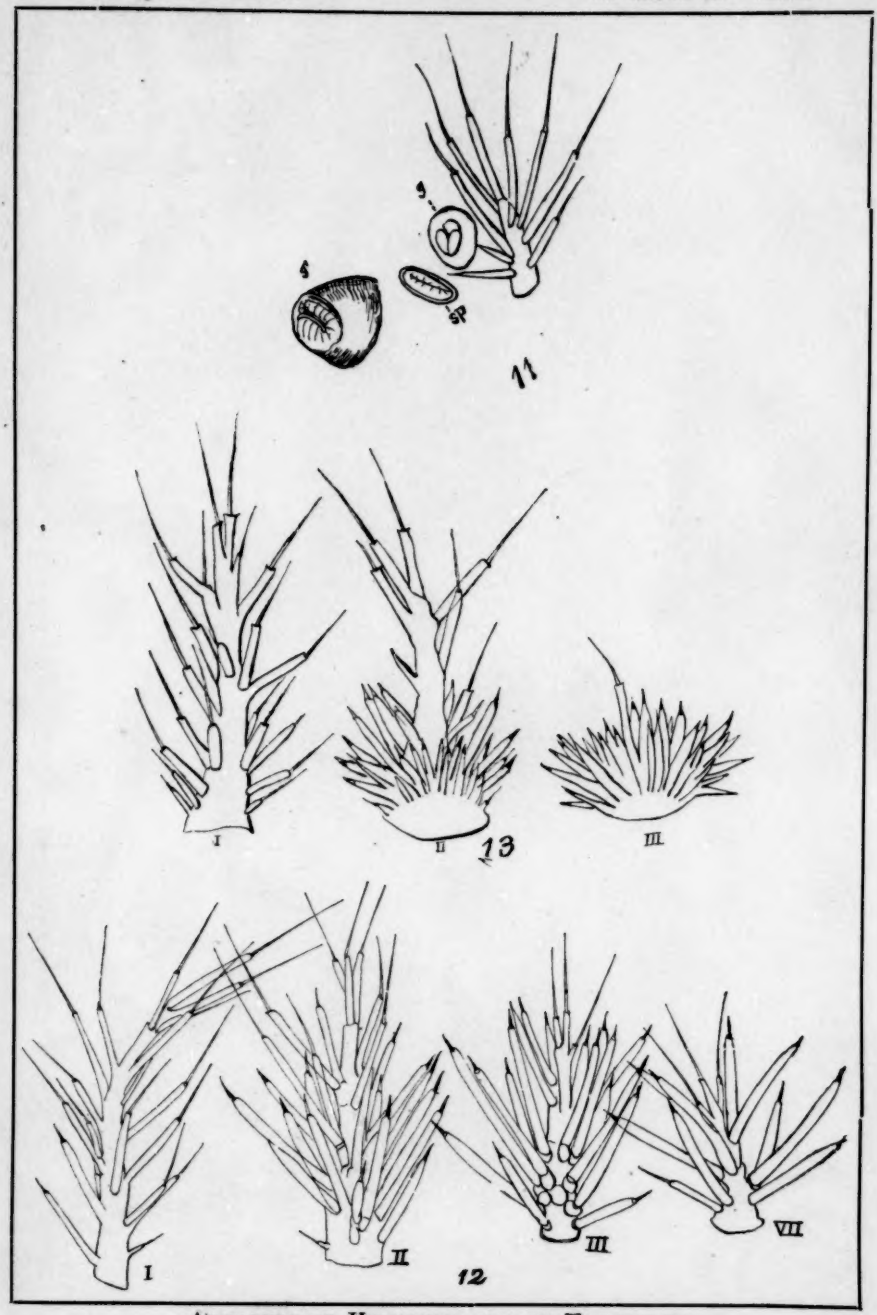
ARMATURE OF EACLES IMPERIALIS.



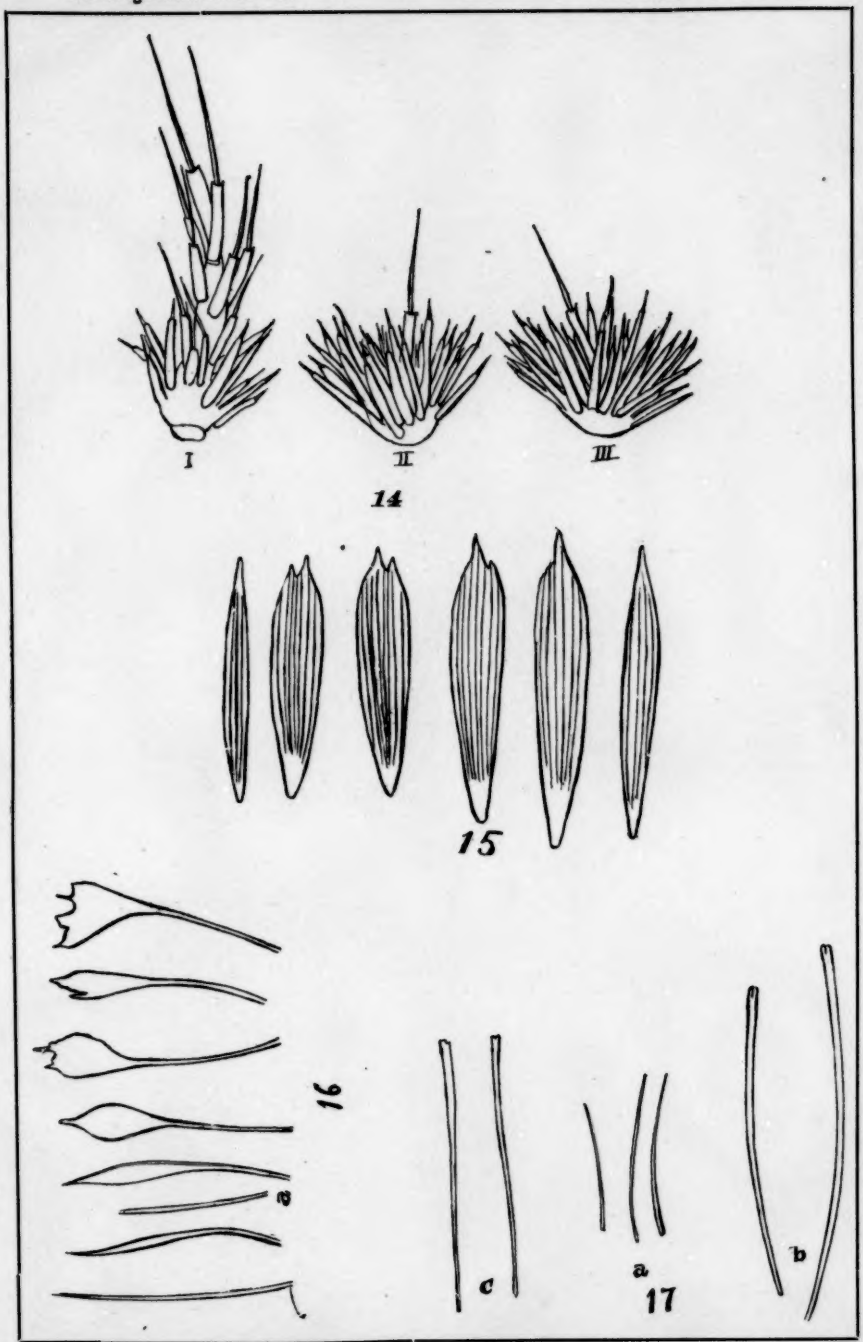
ARMATURE OF CITHERONIA REGALIS AND OF HYPERCHIRIA IO.



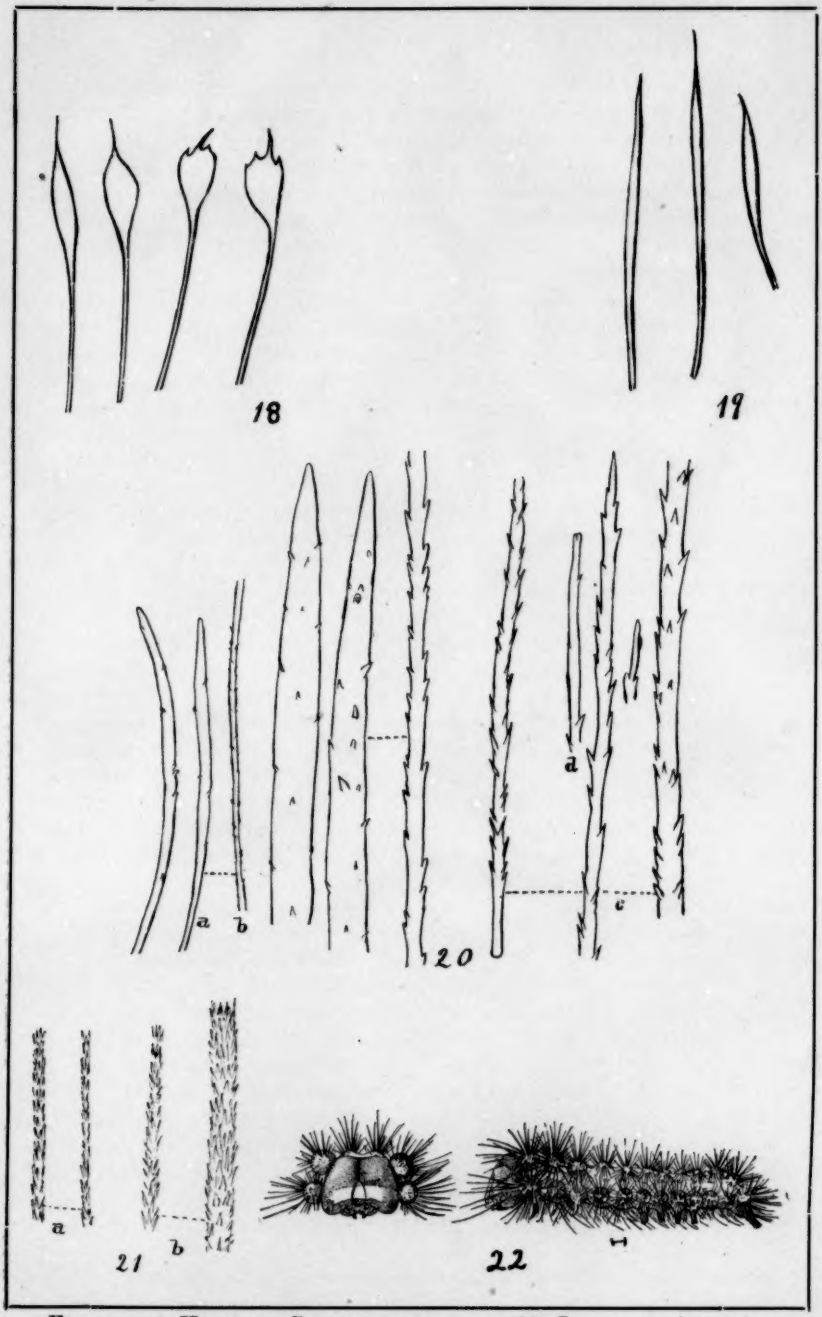
Armature of Hyperchiria io.



ARMATURE OF HEMILEUCA AND OF HYPERCHIRIA.



ARMATURE OF HEMILEUCA YAVAPAI AND SCALES OF GASTROPACHA.



FLATTENED HAIRS OF CATERPILLARS, AND (22) LARVA OF ARTACE.

Hæckel also proposed for the process of the development of the individual the term *ontogeny*, genesis of the individual being. The displays of energy, in time and space, controling the process of development, both racial and individual, that is, the *phylogenetic* and *ontogenetic* processes, are now admitted on all hands to run more or less closely parallel. When old characters tend to reappear very early in *ontogeny*, it is explained that this is a case of reversion, atavism or *palingeny*. If, on the other hand, a new character tends to appear very late in the ontogeny, it is explained that it is because such a feature was late in appearing in the phylogenetic or racial history, it is therefore said to have arisen from comparatively recent variations of the type form, or to be *cænogenetic*. The regis'ration upon the germinal matter of organisms of these developmental tendencies to reappear in a certain sequence and relation, in time and space, comprehends what is generally understood by the term *heredity*.

Hereditary phenomena are therefore *ontogenetic*, and in so far as the latter repeat an ancestral history they are *phylogenetic*. That is, the energies of individual development reflect or epitomize in the sequences and relations of their display those which have attended the evolution of the race.

Thus far the use of these terms, which have become current and well understood in biological literature, seems to be justified, in that they stand for a formula which is so largely true in spite of occasional discrepant facts that we must accept these words as brief or shorthand expressions for two great biological principles.

Adaptation of the organism to its conditions of life is now, as it always has been, a very difficult subject. Some have supposed it to be due to variation of the potentiality of the germinal matter derived from the two sexes, or to *Amphimixis*, and that the individual variations thus produced that were unfitted for survival were eliminated by natural selection. Others have maintained that there is more or less evidence of the occurrence of direct adaptation or adjustment of the organism to its surroundings with accompanying variation, and that consequently the energies developed within and without the organism had to do with the process of adaptation and the origin of variations. The development of adaptations was, therefore, according to this latter view, a resultant consequent upon the interaction of two sets of forces, namely, those developed within and also those developed without the organism. Natural selection in this case was also supposed to be operative as the agent eliminating the unfit. Weismann, Lankester and others have defended the first view. Hæckel, Cope, Spencer and even Huxley (the latter with some reserve, perhaps) have supported the latter opinion. Darwin himself was inclined to the last to ascribe a certain influence to external agencies, and also to use and disuse, in doing which he showed his leaning towards what has since his death been regarded as the more distinctly Lamarckian view of the origin of variations.

Prof. Cope has sought to establish a recognition of the factor of energy

as developed in the motions of organisms and their parts as an agency in the modification of the forms and proportions of their hard parts. In this he has distinctly followed Lamarck, Spencer and the writer, and to this agency he has applied the term *kinetogenesis*, which may also be written *kinetogeny* in order to make its Anglican spelling conform to that of the very useful terms proposed by Hæckel.

Unfortunately this term, *kinetogeny*, does not embrace a consideration of all the forms of energy that concern the problem of adaptation. My only reason, therefore, for invading this field of terminology is that there appears to be a need for another term which shall be more comprehensive and which shall apply to all the forms of energy involved in a study of adaptive processes, namely, the potential or static and the actual or kinetic. This will embrace both the energy of rest or equilibrium and that of motion or lack of equilibrium. The most general term that can be used for this purpose seems to be *ergogeny*, the etymology of which is apparent. This general term, *ergogeny*, will include not only *kinetogeny*, but also its antithesis, *statogeny*.

If an organism suffers morphological modification in consequence of the display of the energy of motion, any modification thus caused would be developed kinetogenetically. If, on the other hand, an organism were modified in such a way that the energies developed by it were in a condition of statical equilibrium, and, moreover, if its specific form depended upon the maintenance of such a statical balance, then any formal modification thus caused and maintained would be developed *statogenetically*. If it is meant that energy has been concerned in producing a certain modification without specifying the kind of energy, such modification may be said to have been produced *ergogenetically*. Concrete illustrations will, however, be necessary in order to give a clear notion of the very real difference that exists between the two processes, namely, *kinetogeny* and *statogeny*, embraced under the still more general term of *ergogeny*.

If the motion of the developing parts of an organism condition their structural modification in a definite and precise way, as in the case of the development of vertebral centra, of the vertical rows of scales on fishes, or the fractures across the fin rays of certain fishes, as I have shown elsewhere,* then the effects so produced are developed ergogenetically. In that such effects are the result of the expenditure of energy in the form of motion they are also developed kinetogenetically.

If, on the other hand, the process is one in which the energy developed is a consequence of growth itself, and is dependent merely upon the gross physical and statical properties of the living matter itself, such as the varying surface-tension of different parts of the surface of the plasma, then the problem becomes one, not of motion, but of the want of motion, of forces in equilibrium or a statical one. Such conditions of statical equilibrium of surface-tensional forces of the adjacent surfaces of the cells of

* "Proofs of the Effects of Habitual Use in the Modification of Animal Organisms," *Proc. Amer. Philos. Soc.*, Vol. xxvi, Nov. 21, 1889.

the early stages of segmenting eggs are known by the thousand to the skilled embryologist.

In that these cannot at first be overmastered by either phylogenetic or ontogenetic forces, or by both combined, proves that the forms so developed are, therefore, the resultants of the energy represented by the phylogenetic and ontogenetic or the sum of the hereditary forces working in antagonism against a recurring statical condition of the substance of the germ. This statical condition reasserts itself at the close of every segmentation, so that there is a recurrent conflict between these two sets of forces at every step of development. In fact, the round or oval form of the egg is a statical condition of the germinal mass dependent wholly or partially upon its own surface-tensional properties. That this is gradually overcome in the course of the ontogenetic process is well known, but it is also a fact that no known form of animal or vegetable development is exempt from the influence of the interference of statical forces of equilibrium, mainly those of surface-tension. In so far, therefore, as the form of the early stages of the development of an embryo are thus interfered with, such modifications are statogenetic. The great generality of this principle, therefore, becomes apparent. The generality of statogeny is, in fact, coextensive with that of phylogeny and ontogeny. But this is not all. Every statogenetic state alternates with a kinetogenetic state, since every new statogenetic condition is heralded by a kinetogenetic one. It is this incessant organic and organizing seesaw of processes that is comprehended under the still more general term of ergogeny.

Such must, therefore, be my excuse for adding this new set of terms to those already in use, since they represent a series of processes of such universality as to be of an importance second only to those of phylogeny and ontogeny. To illustrate in detail the great variety of phenomena with which ergogeny and its forms, kinetogeny and statogeny, have to deal would much transcend the purposes of this paper. Only sufficient additional examples will therefore be given to show the far-reaching character of these principles.

In the motion of *Amœba proteus*, kinetogenetic phenomena either alternate rhythmically with statogenetic phenomena, or perhaps more correctly, both constantly accompany one another in the course of the movements made by this very simple organism. The chemical processes within the Amœba by means of which its surface-tension is constantly being disturbed are kinetogenetic, since this equilibrium or statical balance of the plasma is thus recurrently overthrown. This leads to a temporary rupture of the surface layers of molecules and an intrusion of new molecules from within to repair the rent. When this is accomplished a statical equilibrium is temporarily restored only to be followed by a recurrence of motion or overthrow of statical equilibrium. This leads to the more or less fitful or interrupted motion seen in these organisms. These alternating and conflicting processes also determine the figure of the organism at every instant, so that ergogeny becomes, in the lowest forms, through its elementary

types of kinetogeny and statogeny, form-determining or morphogenetic. The development of the figure of the body of *Amœba proteus* is also partially conditioned by cohesion to adjacent surfaces, and is also, to some extent, pulled upon as a semifluid mass by gravity and flattened. The vortical flux of its own particles through themselves also elongates it in the direction of its own motion. This causes the anterior end of the organism to present a tense, rounded outline, while its posterior end is wrinkled, papilliform or uneven. The vortical flux of particles in the centre of the body of the organism flow fastest while they gradually move slower towards the surface where the ultimate and outermost layer is at rest. Thus in every detail of its morphology do we discover that Amœba is absolutely the creature of energy conditions. Its shape at every instant of its existence is determined ergogenetically as we may speak of the form-conferring forces developed from within as distinguished from those of gravity, adhesion and cohesion that are operative from without. Even the ideally perfect form of vortex motion of the particles of its substance is disturbed and distorted by the interaction of this complex set of forces. Moreover, since the physical properties of the different species of Amœboids are very different, their kinetogenetic and statogenetic characteristics differ correspondingly, so that their behaviors are very different for this reason. The profound differences of form presented by their pseudopodia are to be partially accounted for on this ground, and partially on the ground of the differing physical constitution of their substance.

The phenomena of motion of plasma or cells may be generally comprehended under the term *cytokinetic*, their statical conditions under the term *cytostatic*. In the same way the active and resting stages of nuclei may be regarded as *karyokinetic* and *karyostatic*. The motion and rest of the centrosomes of cells may be named as their *astrokinetic* and *astrostatic* conditions. These six terms, one of which is already in use, are proposed in order to connect the phenomena of cell division with ergogeny in general. The origin of the motion of the Amœba is to be sought in its own plasma; it is therefore cytokinetic. The alternating periods of quiescence of Amœba are cytostatic; its spherical form in the encysted condition is the result of a perfect cytostatic equilibrium in every direction. These results are also ergogenetic; that is, the changes of configuration due to motion are kinetogenetic; those due to a condition of temporary statical equilibrium are statogenetic.

Osmotic processes in combination with surface tension and reciprocal pressures developed against adjacent structures develop the most manifold changes of configuration. If osmotic pressure is the same in every direction within a cell or a mass of cells, a spherical figure results such as that of Volvox. If, on the other hand, the equal internal pressures are antagonized from without by unequal pressures at different points corresponding modifications of figure are developed. This is illustrated in the most manifold ways in the cells of plants and animals. Such modifications thus caused are largely statogenetic.

If motions of hard parts upon each other tend to alter or deform the modeling of the surface in a particular way, as seems to have been the case with teeth, the process is kinetogenetic. If the basal part of the conical surface of a pointed tooth have its enamel organ folded under constraint during growth in a conical matrix into which it expands by growth more rapidly at its basal region than the walls of this matrix expand, the result is partly kinetogenetic and partly statogenetic.

If the development of a blastoderm be conditioned by surface and interfacial tension in such wise as to cause it to conform to the configuration of double curvature of the yolk mass upon which it extends itself, the result is mainly statogenetic. If an embryo be pressed down into the blastoderm as the result of constraint from above during its growth, and the surrounding non-embryonic area is thus caused to be reflected over it more and more as growth of both embryo and blastoderm go on, an amnion is developed. This process is kinetogenetic so far as the growth and reflection of the blastoderm is concerned, but statogenetic in so far as the permanent molding and retention of the figure of the amniotic cavity is concerned. If fin-rays are fractured or segmented in a regular fashion and in response to the exigencies of the motions of the fin, such a result is kinetogenetic. If the calcifiable matrix developed about a notochordal axis be regularly segmented at points alternating with the intervals between the myotomes by the agency of the motions to which such an axis is subjected during use, the result is again kinetogenetic. If an originally globular egg be distorted into an ovoidal body within a tubular oviduct due to circular pressure, as happens in birds and insects, the result is almost purely statogenetic. An empirical mathematical formula may therefore be written for every variation in the shape of the common hen's egg for a curve which shall account also for its shape.

If, as in the case of the double monsters developed in meroblastic eggs due to karyokinetic disturbances, there is a strong interfacial tensional attraction between the germ and yolk substance, it is impossible to shake the first blastomeres apart as in the case of holoblastic eggs, so that fused embryos or monsters only can be produced from such meroblastic ova. Such a result is statogenetic, that is, statical conditions in the meroblastic egg so far override the ontogenetic processes that fused monsters only are here possible, whereas in holoblastic ova in which the blastomeres can be completely separated two or more distinct embryos can be produced from what had begun its development as a single embryo.

So universal is this interference of the statical conditions of the plasma of segmenting ova with the ontogenetic processes, that not a single metazoan organism can be named the development of which is not thus marred in some way or other. It is often a long time relatively after development has begun that there is any obvious delineation of the embryo. In fact, this cannot take place until the statical energies of surface-tension which have kept the egg globular are overridden. In so far as the ontogeny of any organism is marred by statical conditions of energy-display, its em-

bryonic form is also modified. In so far as such statical interference affects the figure of the organism they are morphogenetic or form-determining. In so far the figure of a developing being is disturbed or modified by statical agencies its figure may be said to be subject to statogenetic influences. No existing larval form has escaped the influence upon its own shape of a constantly active statical equilibrium of its own substance. There is, therefore, a constant struggle going on during development between the phylogenetic and ontogenetic forces, determining the sequence and relations of the successive cleavages of the egg and the statical equilibria that obtain amongst its several parts. Statogenetic processes are, therefore, as constant and universal as the phylogenetic and ontogenetic. One may even go so far as to say that possibly the relations thus tending to be established by statical conditions may tend to become transmissible as hereditary tendencies. Such indeed is the view upheld by Prof. E. B. Wilson in his remarkable paper on "The Cell-lineage of Nereis."* I have myself seen no less than three consecutive recurrences of the same statical conditions in a fish egg, none of which can, for this reason, be definitely proved to be purely ontogenetic.

The facetted eyes of insects are usually hexagonal, but not invariably so. I have found triangular, quadrangular and hexagonal facets in the eyes of Tachinus. Now these different forms are due to disturbances of the statical conditions obtaining between the individual ommatidia during growth of the eye. If the pressure is the same from every direction laterally during growth, a cylindrical eye would result. If the lateral pressure is the same from six points at equal distances apart around each eye, the regular hexagon will result; should any two opposite pairs of the six pressures be less than the pressures from the other two pairs irregularities in the hexagons will appear. If cylinders are grouped so that the side of every one touched the sides of six others, which may be done by bringing their tops into rows in three directions, and if now each cylinder be increased in diameter, there will be pressure developed in six directions diverging at equal angles of 60° from one another, a hexagonal configuration of the ends of the cylinders would ultimately result, provided they were formed of plastic material. The same thing sometimes happens when a plastic and nearly homogeneous mass cools and contracts, when cracks appear in the mass generally dividing it into pentagonal and hexagonal prisms, as happened in case of the cooling of intruded mass of molten basalt in the Giant's Causeway in Ireland. A series of cylinders arranged so that every one shall touch six others is also most economical of space, and in the processes of growth is the natural result of a statical equilibrium due to equal pressure from six directions in a plane. If a series of cylinders be brought into rows in two directions only, and so as to touch their neighbors at only four points, quadrangular columns would result were the diameter of every cylinder increased against four others, provided all were composed of plastic material. In these ways have the

* *Journ. Morphology*, Vol. vi.

various forms of the facets of the compound eyes of insects arisen. So too the reciprocal marginal interference of the growth at six equidistant points of the scutes of such forms as the extinct Glyptodonts, has developed in such scutes a hexagonal configuration. In these cases growth is the kinetogenetic factor, and the statogenetic factor is the struggle to bring about an equilibrium of marginal pressures during growth, as a consequence of which a hexagonal figure results.

The development of a cylindrical form of the body is also a case where an equilibrium is concerned that is largely statical in character. The tense condition of its fluid-containing cavities, such as the alimentary canal, will confer upon such an organ a cylindrical configuration; so also in the case of blood vessels. It is indeed probable that the very form of the blood corpuscles or disks is discoidal in virtue of a statical equilibrium of their substance within the fluid plasma in which they are immersed, and that there is a double vortical flux of the substance of these disks from the centre to the periphery on both faces, or the reverse. This vortical flux is probably maintained by the exigencies of metabolism and calls for the incessant exhibition of a tendency towards a condition of statical equilibrium. In this way we may conceive that the thousands of millions of red blood disks coursing through our vessels are enabled to not only maintain their flattened configurations, but to also thus greatly increase the areas of their surfaces and be thus rendered more efficient agents in the processes of oxidation and deoxidation. Here is a statical condition, as we may suppose, that has been adaptively developed through the direct expenditure of energy, by the matter of the corpuscle itself. In other words, our red blood corpuscles have, in the first place, and with the utmost probability, acquired their present configuration ergogenetically. If this is true in the case of the blood disks of ourselves, it is probably also true of the blood disks of all other forms.

The globular form of the egg is a statically developed condition, so is that of the more or less nearly globular morula and also of the blastula; but in the latter internal osmotic pressure is also a factor. Even the brain shows in its earliest form the tendency to develop as vesicles under statical conditions. Here its growth is the kinetogenetic factor, and the tendency for the hemispheres to be at first globular vesicles is owing to the statical influence of the substance composing their walls. Later, as these vesicles grow, they press upon each other along the median line when they present a flattened aspect towards one another from the operation of the same causes, and we at last have developed the "hemispheres" of anatomists. In this way it results that a single somewhat globular body is formed, made up of two halves. Under constraint within the membranous cranial walls the latter conform to this pressure of the growing brain-globe within and conform to its shape, so that a somewhat globular cranium results. Following in detail the evolution of the fissures of the brain, even these are developed kinetogenetically through growth; the pallium or cortex under restraint within the skull grows and shows a tendency to

have its wall folded into ridges, with intervening fissures that tend, for assignable mechanical laws, to join one another at an angle of 120°, as first pointed out by the late Dr. A. J. Parker, and, as it seems to me, correctly attributed by him in part to ergogenetic influences. It may also be shown that the heart, in the course of its development, gives evidence of being subject to the morphogenetic influence of ergogeny.

The spiral or torsional form of many of the articular faces of the ends of bones in the limbs of terrestrial vertebrates can probably be shown to be associated with the development of torsional stress in locomotion. That such torsional stress is actually developed during the locomotion of terrestrial vertebrates has been conclusively proved by Prof. Allen from a careful study of the work of Muybridge upon animal locomotion. Upon every hand, therefore, there is evidence of structure that has been developed in conformity with the conditions of the expenditure of animal energy. I have myself called attention to the fact that digital reduction first began in the hind limbs or in those subjected to the greatest stress, in leaping, by land vertebrates. The forelimbs show this tendency later and in conformity with the fact that they cannot become the channel for the dissipation of such large amounts of energy, impulsively, as the hind ones. Digital reduction and specialization is therefore to be regarded as having been induced and begun ergogenetically.

In the course of other work I have had occasion to call attention to the fact that the foundations of the skeleton were in every case laid down in certain comparatively inactive, or, as I have elsewhere expressed it, ametabolic tracts. These tracts were either external, protective non-plasmic envelopes or they were developed between the organs. In both cases they tend to take the form of intercellular or circumcellular matrices, or as matrices laid down between organs. Metabolism is *nil* in them everywhere because of the non-plasmic and the non-metabolic character of their substance. Such matrices, therefore, present from the lowest protozoa up to the highest metozoa tolerance of inert foreign matters within their substance. Such matrices being colloid, they often attract inert calcareous or silicious matters that are held in solution in the circulating fluids as deposits, just as such deposits are seized and held under laboratory and non-vital conditions by colloids in the presence of hypersaturated solutions. In other words, there is here a tendency to revert to a statical condition on the part of these inert salts, which thus tend to crystallize within such a matrix and within the living body. These matrices are thrown out as a protection, or as the result of irritation of cell tracts, or to increase the volume of an organism; the colloids of which they are composed attract the inert calcareous or silicious salts that pass through the living and adjacent plasma and a statical equilibrium is thus restored. The skeletal matrix thus calcifies, as we express it, whereas the truth is that we are probably dealing with a phenomenon that differs but little in its essential nature from one that may be imitated in the laboratory. The process is one that ultimately develops a statical equilibrium when the

matrix is saturated with inert silicious or calcareous materials. This may be especially well shown in regard to the wonderfully complex shells of Radiolarians, Foraminifera, the spicules and skeletons of sponges, the shells of the eggs of birds, the calcification of bone and cartilage, etc. I therefore very much question whether there is a single skeletal structure anywhere to be met with, the development of which does not take place in some measure statogenetically. Especially is this true of the configuration of the skeletons of such complex objects as Radiolarians, Foraminifera, etc., where surface tension coöperating with the process of the gradual statogenetic saturation of the matrix gives to them their wonderful complexity and beauty. While such phenomena as those of the genesis of the heterocercal or upwardly deflected condition of the axis in the tails of fishes, or the downwardly deflected condition of the axis in Ichthyosauri are almost purely kinetogenetic, the multiplicity of factors concerned, statogenetic as well as ontogenetic and phylogenetic, must always be considered and each given its due weight and importance in achieving the morphogenetic result. That there is an absolute conflict between statogeny and kinetogeny on the one hand, and of phylogeny and ontogeny on the other, in the case of the development of the ova of multicellular forms admits of no doubt. All metazoa pass through larval stages in which the statical condition of equilibrium of the plasma of the egg is gradually, in a great measure, overridden by the hereditary energies represented by phylogeny and ontogeny. That there still remain traces of the effects of kinetogeny and statogeny in the adult organism cannot be denied in view of the facts to be derived from the shapes of tissue elements, and even of organs, as the foregoing paragraphs show.

These few observations and reflections will, I think, at least make it clear that the terms *ergogeny*, and its forms of *kinetogeny* and *statogeny*, are justified, and that they stand for what constitutes a very important part of the machinery of organic evolution, the generality and importance of the influence of which is certainly not less than second to that of phylogeny and ontogeny. The energy factor or ergogeny left entirely out of consideration must therefore seriously cripple the symmetry and completeness of any general theory of organic evolution.

Appendix.

The introductory chapters to Hæckel's great work on the Radiolaria, forming part of the series of *Challenger Reports*, contains much that is suggestive in relation to the subject of this paper. Also papers by Dreyer and others in the *Jenaische Zeitschrift*, in reference to the ergogenetically developed forms of the tests of Radiolarians, Rhizopods and Foraminifera. The botanists have long since appreciated the importance of this subject, and Berthold's *Protoplasmechanik* is an especially suggestive work. Sachs has also contributed to the subject. Much that is suggestive is also to be found in the *Principles of Biology* of Herbert Spencer, though his facts

are not invariably to be depended upon, owing to the very different interpretations now to be given many of them. Papers by Cope on the mechanical development of the structure of the hard parts, teeth and joints, are to be found in the *American Naturalist, Journal of Morphology* and *Proc. Amer. Philos. Soc.* Prof. Hyatt has also published several important papers on this subject, especially in reference to Molluska. Suggestive papers have also been published in this connection by Dr. W. H. Dall, while Lang has considered the development of the shells of univalve mollusks from a mechano-physiological standpoint in his *Lehrbuch d. Vergleichenden Anatomie.*

Purely physical papers by Plateau, Mensbrugghe, Quincke and others are also important as well as the experimental and biological results published by O. Bütschli and H. Virchow.

The subjoined list of papers by the author of the foregoing paper embraces the principal part of what he has published upon the ergogenetic development of morphological characters in the animal kingdom:

On the Laws of Digital Reduction, Am. Naturalist, 1877, pp. 603–607. Nature, xvii, 1877, p. 128.

On the Mechanical Genesis of Tooth-forms, Proc. Acad. Nat. Sciences, Philadelphia, 1878, pp. 45–80 (Abstr. by C. N. Peirce).

Dental Cosmos, xx, 1878, pp. 465–472.

Further Notes on the Mechanical Genesis of Tooth-forms, Proc. Acad. Nat. Sciences, Philadelphia, 1879, pp. 47–51. Review of by E. D. Cope, Am. Naturalist, 1879, pp. 446–449.

On the Origin of Bilateral Symmetry and the Numerous Segments of the Soft Rays of Fishes, Am. Naturalist, xiii, 1879, pp. 41–43.

The Gigantic Extinct Armadilloes and Their Peculiarities, With a Restoration, Pop. Sci. Monthly, xiii, pp. 139–145. 4 figs. [Discusses the mechanical genesis, degeneration, and coalescence of vertebral centra.]

The Significance of the Diameters of the Incisors of Rodents, Proc. Acad. Nat. Sciences, Philadelphia, 1877, pp. 314–318.

On the Position of the Yolk-blastopore as Determined by the Size of the Vitellus, Am. Naturalist, 1885, pp. 411–415.

On the Availability of Embryological Characters in the Classification of the Chordata, Am. Naturalist, 1885, pp. 815–819 and 903–907.

On the Genesis of the Extra Terminal Phalanges in the Cetacea, Am. Naturalist, 1885, pp. 1013–1016.

An Outline of a Theory of the Development of the Unpaired Fins of Fishes, Am. Naturalist, 1885, pp. 90–97.

The Origin of the Amnion, Am. Naturalist, 1886, pp. 179–185.

On the Origin of Heterocercy, etc., Ann. Rep. U. S. Com. of Fish and Fisheries for 1884, pp. 981–1085, Pl. ix, 1886.

A Theory of the Origin of Placental Types, etc., Am. Naturalist, 1887, pp. 780–784.

On the Homologies and Early History of the Limbs of Vertebrates, Proc. Acad. Nat. Sciences, Philadelphia, 1887, pp. 344–386.

On the Development of the Cetacea, etc., Ann. Rep. U. S. Com. of Fish and Fisheries for 1885, pp. 427–485, Pl. iii, 1887.

A Physiological Theory of the Calcification of the Skeleton, Proc. Am. Philos. Society, xxvi, 1889, p. 9.

The Polar Differentiation of Volvox, etc., Am. Naturalist, 1889, pp. 218–221.

The Quadrate Placenta of *Sciurus hudsonius*, Am. Naturalist, 1889, pp. 271–274.

The Origin of Sex, etc., Proc. Am. Philos. Society, xxviii, 1890, pp. 109–159.

The Placentation of the Hedgehog and Phylogeny of the Placenta, Am. Naturalist, 1890, pp. 376–378.

A Geometrical Representation of the Relative Intensity of the Conflict Between Organisms, Am. Naturalist, 1892, pp. 923–929.

On the Mechanical Genesis of the Scales of Fishes, Proc. Acad. Nat. Sciences, Philadelphia, 1892, pp. 219–224.

The Principle of the Conservation of Energy in Biological Evolution; A Reclamation and Critique, Proc. Acad. Nat. Sciences, Philadelphia, 1892, pp. 455–468.

The Inheritance of Modifications Due to Disturbances of the Early Stages of Development, Especially in the Japanese Domesticated Races of Gold-carp, Proc. Acad. Nat. Sciences, Philadelphia, 1893, pp. 75–94.

The Mechanical Genesis of the Form of the Fowl's Egg.

By John A. Ryder.

(*Read before the American Philosophical Society, April 21, 1893.*)

The configuration of the outline of the hen's egg is determined apparently by mechanical means while the egg-membranes and shell are in process of formation within the oviduct.

The conditions, after the passage of the ovum or yolk proper into the oviduct, seem to be about as follows:

1. In the upper part of the oviduct the albumen is laid down upon the yolk by the activity of the albumen-secreting structures forming the wall of the duct. This albumen is laid down in successive layers, as is proved by the structure of the albumen and chalazæ, when these are coagulated by heat and then cut into thin sections. This lamination of the albumen is a result of the mechanical relations that the yolk sustains to the surrounding albumen-secreting surfaces, and this structure of the albumen is mechanically caused. The chalazæ are produced as the first deposits of albumen in the oviduct behind and in advance of the yolk. The twisting of the chalazæ is mechanically caused for the reason that the twist of the chalaza

at opposite poles of the yolk is in opposite directions. This could not occur except under conditions of rotation of the yolk or true egg during the early steps of its passage down the oviduct. The laminæ of the chalazæ are in a continuous spiral scroll such as is developed by a thin lamina rolled upon itself, such as a scroll of paper. This would seem to prove that a rotation of the forming egg was necessary in order to give rise to the phenomena described.

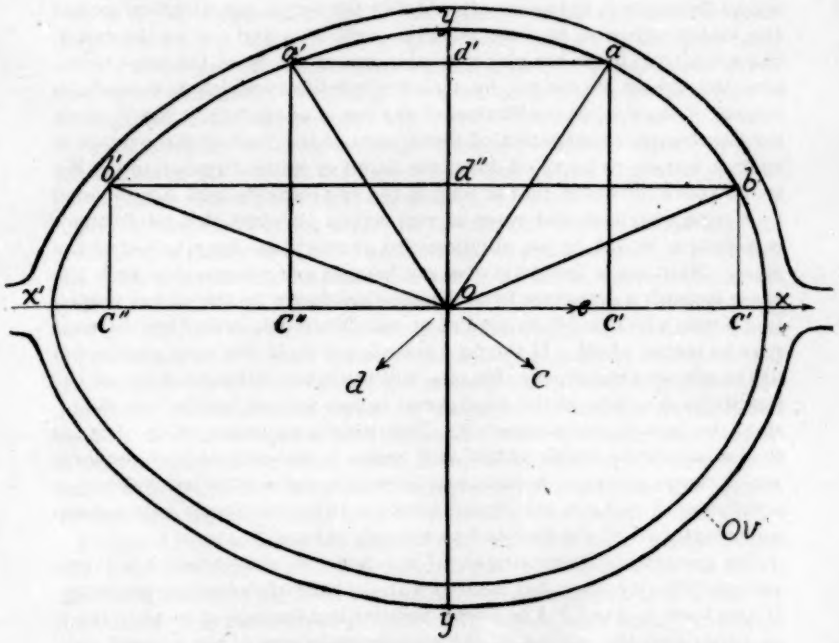
2. The membrana putaminis is deposited in the lower portion of the oviduct. Its fibres are cemented together where they cross one another, showing that they must be formed in a plastic condition. The putaminis, moreover, is laminated, showing that, like the yolk, it is a secretion, the laminæ of which are deposited in succession. It finally covers the entire egg and albumen as a secondary egg envelope, and possesses certain characteristic traits of figure, firmness and elasticity.

3. From the beginning of the process of the development of the secondary egg envelopes in the oviduct there is circular constraint around the yolk and albumen owing to the tubular shape of the oviduct itself. The walls of the latter press upon the contained egg somewhat after the manner of a broad elastic girdle. This pressure around the egg elongates the whole mass in the direction of the long axis of the oviduct. If this pressure of the elastic walls of the oviduct were not associated with peristalsis of the oviduct, in other words, were the forming egg to remain at rest within the duct, it would be deformed only from a spherical to an elliptical figure. This restraint is least at the ends of the mass where it tends to be extended into the lumen of the duct. This elastic annular compression of the forming egg within the oviduct may be regarded as the true cause of the deformation of the hen's egg towards a stable elliptical configuration, while still in the plastic state.

4. After the completion of the membrana putaminis a third homogeneous layer is deposited upon the latter in which the shell is formed. This shelly deposit consists at first of isolated circular nodules of calcareous matter, that only become fused together at a late stage of their deposition ; when in fact they commence to become crowded against one another and pressed into close contact as they enlarge from within outward. Previous to this fusion the shell is flexible, if an egg is prematurely laid with an imperfect shell, as every farmer's boy knows. After the fusion of these minute calcareous plates the shell becomes rigid, as seen in a fully matured egg. It is probable that a certain differential of pressure has been maintained at opposite ends of the egg during the formation of the membrana putaminis, the matrix of the shell, and the shell itself that is instrumental in giving to the hen's egg and birds' eggs in general their particular forms. This differential of pressure at opposite sides of the elastic girdle formed round the egg by the oviduct is caused by the physiological necessity of propelling the egg down the oviduct, or, in other words, is due to the fact that the egg is moved along by forces developed within the wall of the oviduct itself. As this differential of pressure increases on one of the sides of the oviducal

girdle round the egg will the form of the latter depart more and more widely from the figure of a true ellipse and become more and more ovoidal or egg-shaped.

The problem of the development of the figure of the hen's egg is one that may be very easily dealt with mathematically. In fact, judging from the great variety of variations of form presented by eggs it is probable that a different equation would be required for every case, thus showing that the forces operative in the process were themselves variable, a result which is *a priori* most probable. The pressure preventing the passage of the elliptical mass down through an elastic tube must be developed



largely in the form of friction, and the resistance of the walls of the oviduct to dilation. To overcome this a greater pressure must be exerted on the elliptical egg-mass at a point above its minor axis than below the latter. This will tend to squeeze part of its substance, since it is at last enclosed in an elastic capsule before shell formation takes place, into the lower or larger end of the mass. In this way the ovoidal form of the egg seems to have first arisen. The mechanism by which this is accomplished can, however, be best understood by means of a diagram showing the manner and conditions under which the forces involved coöperate.

If the wall of the oviduct *Ov* is supposed to conform to the shape of

the egg and to be closed in front and behind it, in a longitudinal section of the egg in place in the oviduct, we should obtain a diagram* somewhat like the foregoing. The major axis of the egg coincides with x, which produced is also coincident with the closed lumen of the oviduct. The minor axis y is transverse to the oviduct. If it is sought to move the egg within the oviduct, dilated as it is, at the point where the egg lies, a certain propulsive force must be developed annularly by the circular fibres in the wall of the duct. This requires that the force exerted from x' to y shall be greater than that exerted from x to y, else the egg will not be moved along x in the direction of e. This implies that the annular muscular coat in the wall of the oviduct shall contract with greater energy from x' to y than from x to y, but as a matter of fact the egg is not elliptical so that the major axis x is cut into unequal parts, x' o and o x by the axis y. Since this true, if the annular muscular coat of Ov be of the same thickness throughout its length by the very conditions which now obtain in respect of the statical equilibrium of the figure of the egg, it would, upon the simultaneous contraction of those parts of the wall of the oviduct in contact with it, be impelled down the latter, or in the direction of e. We stated above, however, that so long as the egg contents were not confined to a rigid envelope and were at rest within the duct that the figure of equilibrium would be an elliptical one through the long axis x of the mass. Now this is just what does not happen and we can only seek the cause for such a departure from the elliptical figure in the added propelling force which must be applied at one side of y in order that the mass may be moved at all. If the fluid mass is not rigid the very application of the greater force on one side of y will cause the elliptical figure of the longitudinal section of the mass at rest to pass into an ovoidal one the instant the mass is put into motion. This simple statement of the facts as to the conditions which obtain will make it self-evident that the force which causes an egg to become ovoidal within the oviduct is developed as a differential of force manifested between two immediately adjacent annular segments of the duct and on opposite sides of y.

The geometrical demonstration of this fact is so simple that it will present no difficulty to any one familiar with the rules of elementary geometry. If two lines a' a and b' b be drawn parallel to x through y, so as to touch at either end the outline of the semicircumference of the egg and ordinates be then erected, as a c' and b c' and a' c'' and b' c'', four rectangles will be formed which will completely exhibit the quantitative antagonism of the forces developed symmetrically upon either side of y or of x. The two rectangles, a' d' c'' o and b' d'' c'' o are greater in area than the rectangles a d' c' o and b d'' c' o on the other side of y. The sum of the diagonals a' o and b' o of the first pair to the left is greater than that of a o and b o of the second pair to the right of y, therefore the sum of the former as representing the propelling energy developed by the pressure

*This diagram has been constructed from the outline of a hen's egg very carefully plotted. It therefore represents an actual contour.

of the oviduct from x' to y must be greater than the sum of the first pair representing the resistance developed by the walls of the oviduct from y to x. It is this difference of annular pressure thus developed between x' and y along the curve and y and x along the remainder of the same curve that is responsible not only for the energy which propels the egg along the oviduct, but which also deforms it while in a plastic condition, before rigid membranes are deposited over it, and causes it to permanently assume the ovoidal figure so familiar to every one in the form of the hen's egg.

Pursuing the analysis further, the composition of forces developed from x' to y would take the direction c. Those from y to x would take the direction d. A similar set would be developed from the two inferior quadrants below x, but these we may neglect, since they are of the same value exactly as the pair of antagonistic energies already considered and developed above the axis x. Since $c > d$ the tendency will be for the mass to be propelled in the direction of e and there will thus be a second composition of antagonistic forces in the direction of e which will not only propel the egg along the oviduct, but also tend to deform the egg-mass prior to its becoming encased in a rigid egg-shell.

The development of the figure of the eggs of birds is therefore in all probability a purely dynamical problem or one in which energy is applied in a definite manner to the plastic surface of a mass in statical equilibrium within the oviduct. The moment motion is set up to propel the egg through the duct the forces operative in determining the figure of the as yet unformed shell depend upon the physiological activity and condition of tone of the muscular walls of the oviduct which must first deposit the membrana putaminis, the figure of which as a somewhat elastic closed membrane is determined as here supposed. This in turn definitely determines the figure of the shell, which is deposited upon it. In this way it can be shown that the interplay of energies developed by the soft parts or oviduct have determined the conformation of a hard part or of the shell.

The shell itself is, however, deposited by a process involving the development of a statical equilibrium which is finally satisfied when the development of the shell has been completed. What is meant here is that the shell-matrix is a non-cellular colloidal body which has a strong attraction for soluble, inert, earthy substances such as lime salts, circulating in the fluids of the body. These being particularly abundant, partly as excreta, in the vicinity of the cloaca, near which the shell of the eggs of birds is formed, the source of the supply of these matters is not far to seek. These soluble but inert salts are attracted by this colloidal matrix which they finally saturate when the shell may be said to be completed.

The shell of the eggs of birds has therefore probably been developed statogenetically, while the figure of the shell has been developed kinetogenetically. Both factors are, however, ergogenetic, that is, form and structure has here been developed by the expenditure of energy.

That there has been great variation in the mode of exhibition of the

kinetogenetic factor in the development of the shells of eggs is proved by the fact that the latter vary in form very widely. So much is this the case that a distinctly different algebraic formula would have to be worked out for every variation of the form and size of eggs laid by even the same bird. If the very slight disturbances of the counterpoise of the energies on either side of the axis *y* which condition and determine the figure of such a body as a hen's egg are sufficient to produce the remarkable variations which we may see by the thousand in any marketplace, how slight must be the disturbances of the interplay of the living energies that need to be set up in living bodies in order to produce the endless number of variations that they present. If the figure of the hen's egg is dependent upon the mode and condition of the equilibration of forces developed within an oviduct, what reason is there to doubt that plastic organisms are so modified, only in ways a thousand times more complex and difficult to unravel and explain.

The application of the principle here developed is very extensive. It applies also to an explanation of the oval and ovoidal forms of the eggs of many animals that are manifestly due to causes operating in much the same way. Those of many insects at once occur as a case in point. The elongated blastocysts of mammals growing under a condition of annular constraint within a tubular uterus or uterine tubule are other cases that illustrate the same doctrine. The foregoing discussion also clearly explains why it is that the blunt end of the hen's egg comes down the oviduct as its foremost portion and not the sharp end, as one would be led to suppose, were it not positively established that such is not the case.* It also makes it evident that variations in the figure of the eggs of birds are due to the exhibition of varying quantities of energy and to different conditions of activity of the walls of the oviduct during the formation of the secondary egg envelopes, in the thus protracted process of oviposition.

One may be further permitted to surmise that in its nearly completed state in the oviduct that the prolonged and at first voluntary retention of the egg in the latter by the parent distinctly tended to cause the deposit of the third and last homogeneous matrix into which calcareous infiltration occurred automatically as suggested above. The retention of the egg in the oviduct caused it to act as an irritant when a second and last basement membrane, the matrix of the future shell, was thrown down in the oviduct comparable to that of the basement membrane or zona deposited around the ovum as the vitelline membrane in the ovarian follicle. The evolution of the eggshell itself may, therefore, with the utmost show of probability, be traced to a voluntary and more or less intelligent desire of the female parent to protect its potential offspring for a time within her own body. In carrying out this protective instinct which preceded the habit of nest-building, concealment or burial of the whole laying was resorted to, as still practiced by reptiles, such as alligators and turtles. The entire brood or nestful were also at first laid at once and concealed, and a

* The evidence for this was first adduced by Nathusius, *Zoolog. Anzeiger*, Vol. viii.

crude egg-burrow only, without subsequent parental care, as in the case of Pityophis, was constructed. We can thus understand that the often elaborate and intelligent nest-building habits of Aves were preceded by the far cruder and hastier and simpler nesting habits of the Reptilia, which, on account of the phylogenetic relations between the two groups, should, on *a priori* grounds, be the case.

The origin of the egg-shell of the eggs of birds and reptiles may therefore be traced to physiological causes acting automatically under the control of those instincts or intelligent efforts at self-preservation and protection extended by the parent to the young even while still in the form of the outwardly and apparently quiescent condition of the egg. The prolonged retention of the eggs in the oviducts must have begun in reptiles where the whole laying of a season is found to occupy the oviducts at one time. Such prolonged retention would distinctly tend to develop a shell owing to the operation of agencies that we can in a great measure trace and specify as above. Such a retention of the ova within the oviduct for a period would also distinctly tend to develop the amniote placental and viviparous forms of development, provided the retention of the eggs was from any cause prolonged. There is, in fact, much evidence to indicate that eggshells or secondary egg envelopes were, in the first place, evolved because of the prolonged retention of the eggs within the oviduct by the wary female for purposes of protection. Such a prolonged retention of the eggs in the oviduct was only the prelude to the evolution of placental viviparity and to the highest forms of parental care as exemplified in the human species. Both processes were, therefore, adaptive as they were also manifestly superposed in the order of their development. The mechanical genesis of the amnion was begun in fishes, and was completed amongst higher forms. Its conditions have been in part traced by the present writer and Dr. T. W. Shore. In the same way the successive steps of the evolution of the allantois may be traced. It may accordingly be shown that the lines of demarcation between egg-laying and viviparous vertebrates are in large measure arbitrary, and that if the evolution of these processes be carefully studied, direct and obvious connections can be established between both. Not only is this the fact, but there also now exist sufficient data to establish upon a tolerably firm foundation the doctrine that the various types of placentation are developed as the results of direct mechanical and physiological adaptation. The evidence for this appears quite as clear as that which has been adduced above in regard to the dynamical method and mechanical conditions under which the form of the eggshell is determined in the oviduct of birds.

Notes on the Classification and Taxonomy of the Testudinata.

By G. Baur, University of Chicago.

(*Read before the American Philosophical Society, May 5, 1893.*)

I. The Type of Hydromedusa tectifera Cope, with General Observations on the Genus Hydromedusa and the Classification of the Pleurodira.

Through the kindness of Prof. E. D. Cope, I have received for examination the type specimen of *Hydromedusa tectifera* Cope. The carapace is totally different from that figured by Boulenger * as *Hydromedusa tectifera*.

1. *Osteological Differences.*—In the diagnosis of *Hydromedusa* Boulenger states the number of neural bones as seven, and in the figure mentioned seven are shown. In the type specimen there are only six neural bones, allowing pleuralia 7 and 8 to meet in the middle line. The neurals are much more slender than in the specimen figured by Boulenger. The first neural is 39 mm. long and extends to the second pleural, excluding neurale 2 from pleurale 1. The first neural measures 6 mm. in front and 15 mm. behind. The second neural is only in connection with pleurale 2. The sixth neural bone is placed between the fifth and sixth pleuralia. The pleuralia 6 do not meet in the middle line, but are separated by the sixth neural and the seventh pleural of the right side, which touches the sixth pleural of the left. The first peripheral (marginal bone) is completely excluded from the second pleural; it is placed between the nuchal and the second peripheral. Notwithstanding the carapace measures over curve 29 cm. in length, it is not fully ossified; there are small fontanelles on the side between the pleurals and peripherals and also between the plastron and the peripherals.

2. *Differences in the Dermal Shields.*—The first vertebral shield is very much longer than broad (58 mm. : 31 mm.); where it meets the posterior cervical shield it is 32 mm. broad; the breadth of the posterior end of the second cervical shield is 68 mm. There cannot be any doubt that the specimen figured by Boulenger as *H. tectifera* belongs to a different species from the type. What name it ought to receive I am unable to determine.

Boulenger considers the specimen figured by Wagler † as *Hydromedusa maximiliani* and that figured by Peters ‡ under the same name as identical species, which he also considers as *H. tectifera*.

There seems to be no doubt that the specimens figured by Peters and Wag-

* Boulenger, G. A., *Catalogue of the Chelonians*, London, 1889, p. 211.

† Wagler, Joh., *Natürliches System der Amphibien*, Pl. iii, Fig. 25–42, 1830.

‡ Peters, W., "Zur Osteologie der *Hydromedusa maximiliani*," *Müll. Archiv.*, 1839, pp. 280–289, Pl. xiv. I may mention here that this paper originally appeared as Peters' Dissertatio Inauguralis, under the title "Observationes ad Anatomiam Cheloniorum," with one plate (Berolini, 1838).

ler belong to two different species. This is at once seen from the structure of the squamosal and frontal.

In the specimen of Peters the posterior ends of the frontals are very slender and *not* connected with the very slender inner branches of the squamosals. In the specimen of Wagler the posterior ends of the frontals are well developed and *united* with the inner branches of the squamosals. There is a frontosquamosal arch in Wagler's specimen, but there is only a supraoccipito-squamosal arch in the specimen of Peters.

Unfortunately, the skull of the type of *Hydromedusa tectifera* Cope is not preserved, and it is therefore impossible to determine whether one of the specimens figured by Peters and Wagler belongs to this species. In spite of the papers of Dr. Günther and Boulenger on the subject, it is now again as undecided as ever. Further studies have to decide about it.

The characters of the genus Hydromedusa Wagler. The skull of Hydromedusa shows a peculiarity which separates it widely from its allied forms, Chelys and Chelodina. In Hydromedusa the posterior nasal openings are of enormous size and the *pterygoids* form their posterior and inner border. In other words, the palatines have no inner process at all to connect the vomer (Peters). This seems important enough to place Hydromedusa in a separate family, *Hydromedusidæ*, with the following characters:

Hydromedusidæ.

A slender parieto-squamosal-, or supraoccipito-squamosal arch. Posterior nasal openings bounded by maxillary, palate, pterygoid and vomer; frontals double; nasals free; premaxillary double.

I also propose to establish separate families for both *Chelys* and *Chelodina*, with the following characters:

Chelyidæ.

A strong parieto-squamosal arch. Posterior nasal openings bounded by maxillary, palate and vomer; frontals double, no free nasals; premaxillary single.

Chelodinidæ.

No parieto-squamosal arch nor supraoccipito-squamosal arch. Posterior nasal openings bounded by maxillary, palate and vomer; frontal single, nasals free; premaxillary double.*

The other genera of the Chelyidæ, in the sense of Boulenger, are:

Rhinemys† Wagler, 1830 = Phrynops Wagler, 1830 = Hydraspis (Blgr.) + Rhinemys (Blgr.).

Platemys Wagler, 1830.

* Baur, G., "The Pelvis of the Testudinata," *Journ. Morph.*, Vol. iv, 1891, p. 352.

† Baur, G., "Note on the Genera Hydraspis and Rhinemys," *Am. Nat.*, May, 1890, p. 485.

Emydura Bonaparte, 1836.*
Elseya (Gray part, 1867) Boulenger, 1889.

These I place all in one family which I call *Rhinemydidæ.*

Rhinemydidæ.

A slender or broad parieto-squamosal arch. Posterior nasal openings bounded by maxillary, palate and vomer; frontal double; nasals free; premaxillary double.

The Chelyidæ, Chelodinidæ, Rhinemydidæ and Hydromedusidæ form one natural group of the Pleurodira, which has been already established by me in 1887,† but without proper name. I propose to call it

CHELYOIDEA. ‡

Fifth and eighth cervical vertebræ biconvex; no mesoplastron; no quadratojugal; vomer present and complete.

The second group of the Pleurodira, which contains the families Pelomedusidæ and Podocnemididæ, may be called

PELOMEDUSOIDEA.

Second cervical biconvex; a mesoplastron; quadratojugal present; vomer rudimentary or absent.

Pelomedusidæ.

Quadratojugal without connection with parietals.
Pelomedusa Wagl., *Sternothærus* (Bell) Gray.

Podocnemididæ.

Quadratojugal in connection with parietals.
Podocnemis Wagler; *Peltocephalus,* Dum. and Bibr.
Erymnochelys Baur.§

Intermediate Extinct Family Bothremydidæ.‖

Vomer well developed; no free nasal bones; dentaries coössified; small mesoplastron present.

January 16, 1892.

* This genus was proposed by Bonaparte, in 1836, in his *Cheloniorum Tabula Analytica,* p. 7, and not in 1838, *Arch. f. Nat.,* i, p. 140, as stated by Boulenger.

† Baur, G., "Osteologische Notizen über Reptilien," Fortsetzung, ii, *Zool. Anz.,* No. 244, 1887, p. 101.

‡ In the *Zool. Anz.*, No. 285, 1888, I had given the names Amesoplastralia and Mesoplastralia to the two groups, among which I placed at this time several fossil forms which do not belong there.

§ Baur, G., "The Genera of the Podocnemididæ," *Am. Nat.,* May, 1890, p. 483 (*Zool. Anz.,* No. 285, 1888; No. 296, 1888).

‖ Baur, G., "Notes on Some Little Known American Fossil Tortoises," *Phila. Ac. Nat. Sci.,* 1891, p. 424.

II. Notes on Some Types of the Testudinata Collected by Spix and Preserved in the Zoölogical Museum at Munich.

Rhinemys.—In my note on the genera Hydraspis and Rhinemys (*Am. Naturalist*, May, 1890), I have stated that the number of the neuralia in *Rhinemys rufipes* Spix, the type of Rhinemys, was not yet known. I have now examined the type specimen and have found that the number is *seven*. All the pleuralia 1–7 are separated by the neurals; the pleuralia 8 alone are in contact.

Emys erythrocephala Spix, 1824.

An examination of the type specimen shows that this species is identical with *Podocnemis unifilis* Troschel, 1848; the name *Podocnemis erythrocephala* has therefore to be used.

Emys amazonica Spix, 1824.

This species is nothing but the *Podocnemis sextuberculata* Cornalia and the *Bartlettia pitipii* Gray, and the name *Podocnemis amazonica* has to be used therefor. The skull shows so considerable differences from the other species of Podocnemis that it seems justified to accept Gray's generic term *Bartlettia* for this form.

The type specimen has six neuralia; in the specimen figured by Boulenger seven are present.

I have to state here that these facts were fully brought out already by the late Prof. v. Siebold. The labels written by him give Spix's original names and Troschel's and Gray's names are added respectively.

I am greatly indebted to Prof. R. Hertwig for the permittance to examine these interesting types and to Inspector Will for assistance given during the examination.

München, August 1, 1892.

III. The Genera of the Trionychidæ.

The generic name *Trionyx* was established by E. Geoffroy St. Hilaire in 1809 * (or 1808 †). Schweigger ‡ had introduced the name *Amyda* in a MS. handed to the French Institut in 1809.

Geoffroy mentions the following species:

Trionyx subplanus Geoffr.
" *ægyptiacus* Geoffr., *Testudo triunguis* Forskal.
" *stellatus* Geoffr., *Testudo cartilaginea* Boddaert.
" *carinatus* Geoffr., one of the American species.

*Geoffroy St. Hilaire, E., "Mémoire sur les Tortues molles, nouveau genre sous le nom de *Trionyx* et sur la formation des Carapaces," *Ann. Mus. Paris*, xiv, 1809, pp. 1–20, Pl. 1–5

†Geoffroy St. Hilaire, E., "Sur les tortues molles," *Paris Soc. Phil. Bull.*, i, 1808, pp. 363–367 (not seen).

‡Schweigger, "Prodromus monographiæ Cheloniorum," *Königsberger Archiv. für Naturw. and Math.*, Bd. i, Königsberg, 1812, pp. 271, 272.

Trionyx javanicus Geoffr., *Testudo cartilaginea* Boddaert.
" *coromandelicus* Geoffr., *Testudo punctata* Lacépède.
" *georgicus* Geoffr., *Testudo ferox* Schneider.
" *euphraticus* Geoffr., *Testudo euphratica* Daudin.

In 1830 Wagler* divided the genus *Trionyx* Geoffr. into two genera—*Trionyx* and *Aspidonectes*.

Aspidonectes is thus characterized: "Thorax cartilagine flexibili limbatus; digiti tres palmæ plantæque unguiculati;" and the following species are named: *Trionyx ægyptiacus* Geoffr., *Trionyx javanicus* Geoffr., *Testudo ferox* Penn., *Trionyx muticus* Les., *Trionyx carinatus* Geoffr.

Trionyx is characterized thus: "Thorax limbo osseo mobili auctus; digiti Aspidonectis;" and the single species *Testudo punctata* Lacép. is noted.

One year later, in 1831, Gray† divides also the genus *Trionyx* Geoffroy in two divisions—*Trionyx* and *Emyda*. Among Trionyx he names *T. ferox* Merr., *T. muticus* Les., *T. ægyptiacus* Geoffr., *T. indicus* Gray, *T. hurum* Gray, *T. javanicus* Geoffr., *T. subplanus* Geoffr., *T. euphraticus* Geoffr. Among *Emyda* he names *Trionyx* (Emyda) *punctata* Lacép.

The characters of *Trionyx* are: "The margin of the shields cartilaginous and the sternum narrow." Those of *Emyda*: "Margin of the shield with a series of small bones in front and behind; limbs covered, when withdrawn, by the valves on the side of the sternum."

It is evident that *Trionyx* Gray is the same as *Aspidonectes* Wagler, and *Emyda* Gray the same as *Trionyx* Wagler; the name *Emyda* Gray can therefore not be admitted. Besides the name *Emyda* had already been used by Rafinesque (*Analyse de la Nature*, Palerme, 1815, p. 75) for *Emys* Dum. A few months later Gray‡ published a "new edition" of his *Synopsis Reptilium*. He now separates Emyda completely as a distinct genus from Trionyx. Meanwhile he had seen Wagler's paper, and he states in the Additions and Corrections, p. 78, "Dr. Wagler keeps the generic name of *Trionyx* for my *Emyda* and uses that of *Aspidonectes* for my *Trionyx*."

In 1832, Bonaparte§ follows Wagler, using *Trionyx* and *Aspidonectes*.

In 1835, Duméril et Bibron‖ propose the new names *Gymnopus* for *Aspidonectes* Wagler and *Cryptopus* for *Trionyx* Wagler, which, of course, cannot be accepted.

* Wagler, Dr. Joh., *Natürliches System der Amphibien*, München, Stuttgart und Tübingen, 1830, p. 134.

† Gray, J. E., "A Synopsis of the Species of the Class Reptilia," pp. 18, 19, Appendix to Vol. ix of Griffith's *Animal Kingdom*, London, 1831.

‡ Gray, John Edward, *Synopsis Reptilium; or, Short Descriptions of the Species of Reptiles*, Part i, "Cataptracta," London, 1831, pp. 44–50.

§ Bonaparte, C. L., *Saggio d'una Distribuzione Metodica degli Animali Vertebrati a Sangue Freddo*, Roma, 1832, p. 13.

‖ Duméril, M. C., et G. Bibron, *Espétologie Générale*, Paris, 1835, Vol. ii, pp. 472, 499.

Fitzinger divides, in 1836,* the genus Trionyx into five sections:

Section 1. *Trionyx*, s. str.
" 2. *Aspidonectes.*
" 3. *Platypeltis.*
" 4. *Pelodiscus.*
" 5. *Amyda.*

The characters of *Trionyx*, s. str., are: "Ossicula marginalia distincta. Os cervicale vertebralibus conjunctum, in tota superficie rugosum. Ossa costalia postica contigua." This section contains *T. granosus* Schweigg. (*T. punctata* Lac.).

The characters of *Aspidonectes* are: "Ossicula marginalia nulla. Os cervicale vertebralibus conjunctum, in tota superficie rugosum. Ossa costalia postica contigua." ("Vertebralia septem; costalia utringue octo.") This section contains *T. javanicus* Geoffr., *T. ægyptiacus* Geoffr., *T. hurum* Gray, *T. indicus* Gray.

The characters of *Platypeltis* are: "Ossicula marginalia nulla. Os cervicale vertebralibus conjunctum, in medio tantum rugosum. Ossa costalia postica contigua." ("Vertebralia sex, costalia utringue septem.") This section contains *T. brogniarti* Schweigg., *T. ferox* Schweigg.

The characters of *Pelodiscus* are: "Ossicula marginalia nulla. Os cervicale a vertebralibus separatum, in medio tantum rugosum. Ossa costalia postica contigua." This section contains *T. sinensis* Wigm., *T. labiatus* Bell.

The characters of *Amyda* are: "Ossicula marginalia nulla. Os cervicale a vertebralibus separatum, in medio tantum rugosum. Ossa costalia postica interposito vertebralibus discreta." This section contains *T. subplanus* Geoffr., *T. muticus* Lesueur, *T. euphraticus* Geoffr.

Bonaparte‡ follows mainly Fitzinger, but uses the generic names *Amyda* Schweigg. and *Trionyx* Wagler.

"AMYDA Schweigg.
† Ossa costalia postica contigua.
1. *Aspidonectes* Fitz.
2. *Platypeltis* Fitz.
3. *Pelodiscus* Fitz.
†† Ossa costalia postica interposito vertebralibus discreta.
4. *Amyda* Fitz.
TRIONYX Wagler."

In 1844, Gray§ gave the following synopsis of the genera:

"A. Sternum broad, with valves over the feet. The margin of the shield supported by bones.
1. *Emyda.* Head moderate, sternal callosities five

* Fitzinger, Leopold, "Entwurf einer systematischen Anordnung der Schildkröten," *Ann. Wien. Mus.*, i, 1836, pp. 119, 120, 127.

Bonaparte, C. L., *Cheloniorum Tabula Analytica*, Romæ, 1836.

§ *Catalogue of the Tortoises, Crocodiles and Amphisbænians*, London, 1844, p. 46.

B. Sternum narrow at each end. The margin of the shield expanded, flexible, thin. Sternal callosities four.

2. *Tyrse.* Head moderate, ovate, narrow in front; lips thin. Ribs eight pair, forming a disk with the vertebræ when young.
3. *Dogania.* Head very large, dilated behind, narrow in front; lips thin. Ribs eight pair, not united in a solid disk until late in life.
4. *Chitra.* Head dilated behind, broad and short in front; lips very large, swollen. Ribs eight pair.
5. *Trionyx.* Head moderate, ovate, narrow in front. Ribs seven pair."

The following species are placed with the different genera:

Emyda—E. punctata, E. senegalensis.
Tyrse—T. gangetica, T. javanica, T. perocellata, T. nilotica, T. rafeht.
Dogania—D. subplana.
Chitra—Ch. indica.
Trionyx—T. ferox, T. muticus.

Gray did not accept Fitzinger's classification, because, he says, the characters given by him "alter with the age of the animals" (p. 50).

It may be noted here that in 1843 Fitzinger* had separated the *Aspidonectes javanicus* Wagl. under the name of *Potamochelys*, without giving any characters.

In 1854, Peters† established the genus *Cycloderma* for *Cyclɔderma frenatum* Peters.

The last work we may mention, before discussing the question, is that of Agassiz.‡

He retains the following genera:

Trionyx Wagler (*Emyda* Gray).
Chitra Gray.
Dogania Gray.
Cycloderma Peters.
Aspidonectes Wagl. (*Tr. javanicus, T. ægyptiacus, T. spinifer, A. asper, A. nuchalis, A. emoryii*).
Platypeltis Fitz. (type, *Tr. ferox* Schweigger, *Tr. gangeticus* Cuv.).
Amyda Ag. (type, *T. muticus* Les.).

It is now the time to discuss the value of the different genera proposed. There is no doubt about *Trionyx* Wagler, for this genus has to stand with *Testudo punctata* Lacép. as the type; *Emyda* Gray and *Cryptopus* D. et B. are synonyms of it.

* Fitzinger, L., *Systema Reptilium Vindobanæ*, 1843, p. 30.

† Peters, W., "Ueber die auf seiner Reise nach Mosambique beobachteten Schildkröten," *Berl. Acad. Monatsb.*, 1854, pp. 215, 216.

‡ Agassiz, Louis, *Contributions to the Natural History of the United States*, Vol. i, Boston, 1857, pp. 394-397.

The question now is, What is the type of *Aspidonectes* Wagler?

Since *Aspidonectes javanicus* = *Testudo cartilaginea* Bodd. is fully figured by Wagler, Pl. ii, Figs. 1–12, and this species is also placed in *Aspidonectes* Fitzinger, I consider it as the type of *Aspidonectes*.

Besides this species, three others are mentioned by Fitzinger with *Aspidonectes*:

T. ægyptiacus Geoffroy = *Testudo triunguis* Forskal.
T. hurum Gray.
T. indicus Gray.

None of these belong to Aspidonectes.

Aspidonectes contains besides the type, *Trionyx formosus* Gray and *Trionyx phayrei* Theob.

Aspidonectes Wagl. may be characterized thus:

Posterior nares reduced in size by the inner and posterior extension of the maxillaries. Alveolar surface of lower jaw with a strong longitudinal symphyseal ridge (*fide* Boulenger). Eight pairs of pleuralia, last pair in contact in the median line; a single neural between the first pair of pleurals.

1. Type, *Testudo cartilaginea* Boddaert.
2. *Trionyx formosus* Gray.
3. *Trionyx phayrei*, Theob.

The genus *Platypeltis* was established by Fitzinger for *T. brogniarti* Schweigg. and *T. ferox* Schweigg. Agassiz retains the genus Platypeltis with *Testudo ferox* Schweigg. as type. But the species considered as *Testudo ferox* Schweigger, by Agassiz, does not represent this species at all, but a new one, which I have called *Platypeltis agassizii*;* and this species belongs to a different genus than *Platypeltis* Fitz.

The *Platypeltis* Fitzinger is the same as *Aspidonectes* Agassiz. The type of *Platypeltis* Fitzinger is *Testudo ferox* Schneider. To this genus belong the following American species:

Trionyx spiniferus Les.
Aspidonectes asper Ag.
" *nuchalis* Ag.
" *emoryii* Ag.

The genus *Platypeltis* Fitzinger (name only) may be characterized in this way: Posterior nares not reduced in size by the inner and posterior extension of the maxillaries. Alveolar surface of lower jaw without a longitudinal symphyseal ridge; seven or eight pairs of pleuralia, last pair in contact in the median line; a single neural between the first pair of pleurals.

The question now is, To what genus does the form belong described by Agassiz as *Platypeltis ferox* and named by me *Platypeltis agassizii*? By

*Baur, G., "Notes on the American Trionychidæ," *Am. Nat.*, Dec., 1888, pp. 1121, 1122.

the study of different skulls I have found that this species Aspidonectes has to be associated with *Trionyx triunguis, T. sinensis, T. californianas, T. swinhoei* and *T. euphraticus.*

The following generic names have been applied to these forms since Fitzinger, in 1836, besides the many names given by Heude :

Pelodiscus Fitzinger, 1836 (*T. sinensis* Wiegm., *T. labiatus* Bell), =
Amyda Fitz., 1836 (*T. euphraticus, T. triunguis*).
Tyrse Gray, 1844 (*T. triunguis, T. sinensis, T. euphraticus*).
Rafetus Gray, 1864 (*T. euphraticus*).
Landemania Gray, 1869 (*T. sinensis*).
Fordia Gray, 1869 (*T. triunguis*).
Potamochelys Gray, 1870 (*T. sinensis*).
Oscaria Gray, 1873 (*T. swinhoei*).

Of all these, *Pelodiscus* is the oldest, and I shall therefore introduce it again.

Pelodiscus Fitzinger (name only).

Posterior nares reduced in size by the inner and posterior extension of the maxillaries. Alveolar surface of lower jaw without longitudinal symphyseal ridge ; seven to eight pairs of pleuralia, last pair in contact in the median line ; a single neural between the first pair of pleurals.

Type, *Aspidonectes sinensis,* Wiegm.

Other species : *P. triunguis* Forsk.
P. swinhonis Gray.
P. euphraticus Daud.
P. agassizii Baur.
P. californianus Rivers.

The genus *Amyda* Fitz. contains the three species *Trionyx cartilagineus, T. muticus* and *T. euphraticus.* Of these, *T. euphraticus* has already been placed in *Pelodiscus.*

The *Trionyx cartilagineus* was placed in a special genus by Gray, with the name *Dogania,* in 1844. *Trionyx muticus* was kept in *Amyda* by Agassiz, in 1857. Both these genera have to be retained, each with a single species.

Dogania Gray, 1844.

Posterior nares reduced in size by the inner extension of the maxillaries. Alveolar surface of lower jaw without a longitudinal symphyseal ridge ; eight pairs of pleuralia, all separated by neurals ; a single neural between the first pair of pleurals.

Type, *Trionyx subplanus* Geoffr.

Amyda Fitzinger, 1836 (name only), Agassiz, 1857.

Posterior nares not reduced in size by the inner extension of the maxillaries. Alveolar surface of lower jaw without a longitudinal symphys-

cal ridge; seven to eight pairs of pleuralia, all separated by neurals; a single neural between the first pair of pleurals.

Type, *Trionyx muticus* Les.

There is one group left, consisting of three species, which cannot be united with any of the preceding genera, but which come nearest to *Aspidonectes* and to *Pelodiscus*. This group consists of the *Trionyx gangeticus* Cuvier, *Trionyx leithii* Gray and *Trionyx hurum* Gray. I shall use the generic name *Isola* for this group proposed by Gray in 1873 for *Trionyx leithii*.

Isola Gray.

Posterior nares reduced in size by the inner extension of the maxillaries. Alveolar surface of lower jaw without a strong longitudinal symphyseal ridge; eight pairs of pleuralia, the posterior ones meeting in the middle line; two neurals between the first pair of pleurals.

Type, *Trionyx leithii* Gray.

The *Trionyx indicus* Gray, placed by Fitzinger with Aspidonectes, has been separated by Gray as long ago as 1844 under the generic name of *Chitra*. This genus, as well as *Pelochelys* Gray (1864), *Cycloderma* Peters (1854) and *Cyclanorbis* Gray (1852), I accept in the way as they have been used by Boulenger in the *British Museum Catalogue*.

I give now a table of the different genera, with the type species and their original locality, and also the names of the other species with their original localities.

Trionyx Geoffr., 1809 (name), *Wagler* (*Emyda* Boul.).

1. Type, *Testudo punctata* Lacépède, 1788.
   Exact locality of type not known, India.
2. *Trionyx vitatta* Peters, 1854.
   Locality of type, Goa, West Coast of British India.
3. *Trionyx scutata* Peters, 1868.
   Locality of type, Pegu, British India.

Cycloderma Peters, 1854.

1. Type, *Cycloderma frenatum* Peters, 1854.
   Locality of type, Zambesi river, East Africa.
2. *C. aubryi* A. Dum., 1856.
   Locality of type, Gaboon, West Africa.

Cyclanorbis Gray, 1852.

1. Type, *Cryptopus senegalensis* Dum. et Bibr., 1835.
   Locality of type,* Senegal, West Africa.
2. *C. elegans* Gray, 1869.
   Locality of type, West Africa.

*The real type of Cyclanorbis is *Cyclanorbis petersii* Gray, 1852, from Gambia.

Aspidonectes Wagler, 1830 (name), *Aspidonectes* Fitzinger (part.) (*Trionyx*, i, B. 2, Boulenger).

1. Type, *Testudo cartilaginea* Boddaert, 1770.
   Locality of type, Java.
2. *A. formosus* Gray, 1869.
   Locality of type, Pegu.
3. *A. phayrei* Theobald, 1868.
   Locality of type, Araccan range, west of Pegu.

Platypeltis Fitzinger, 1836 (name) (*Trionyx*, ii, Boulenger, part).

1. Type, *Testudo ferox* Schweigger.
   Locality of type, Savannah river, Ga.
2. *P. spinifer* Les.
   Locality of type, Wabash river, Ind.
3. *P. asper* Ag.
   Locality of type, Lake Concordia, La.
4. *P. nuchalis* Ag.
   Locality of type, Cumberland river, Tenn.
5. *P. emoryii* Ag.
   Locality of type, Lower Rio Grande river, Texas, near Brownsville.

Pelodiscus Fitzinger, 1836 (name) (*Trionyx*, i, B. 3, Boulenger, part.).

1. Type, *Aspidonectes sinensis* Wiegm., 1834.
   Locality of type, near Makao.
2. *P. swinhoei* Gray, 1873.
   Locality of type, Shanghai.
3. *P. euphraticus* Daudin, 1802.
   Locality of type, Euphrates.
4. *P. triunguis* Forskal, 1775.
   Locality of type, Nile.
5. *P. agassizii* Baur, 1886.
   Locality of type, Western Georgia.
6. *P. californianus* Rivers.
   Locality of type, Sacramento river, near Sacramento, Cal.

Dogania Gray, 1844 (*Trionyx*, i, A., Boulenger).

1. Type *Trionyx subplanus* Geoffr., 1809.
   Locality of type, probably, Ganges.

Amyda Fitzinger, 1836 (name), Agassiz, 1857.

1. Type, *Trionyx muticus* Les., 1827.
   Locality of type, Wabash river, Ind.

Isola Gray, 1873 (*Trionyx*, ii, B. 1, Boulenger).

1. Type, *Trionyx leithii* Gray.
   Locality of type, Poonah.

2. *I. gangetica* Cuv.
   Locality of type, Ganges.
3. *I. hurum* Gray, 1837.
   Locality of type, Ganges (probably).

Chitra Gray, 1844.

1. Type, *Trionyx indicus* Gray, 1831.
   Locality of type, Ganges, Pinang.

Pelochelys Gray, 1864.

1. Type, *Pelochelys cantorii* Gray, 1864.
   Locality of type, Pinang.
2. *P. cummingii* Gray, 1864.
   Locality of type, Philippines.
3. *P. poljakowii*, Strauch.
   Locality of type, Fu-tschan.

It may be seen that in the circumscription of the species I have nearly completely followed Boulenger. This, however, is only provisionary. I am fully convinced that Boulenger has gone too far in contracting species. This I may especially say in regard to his *Trionyx sinensis, triunguis* and *subplanus*. Further detailed studies have to decide about this question.

I do not believe at all that the system proposed here is finished; but I think that it gives a more correct idea of this difficult group of tortoises. Much remains to be done yet for an exact knowledge of the Asiatic and African forms. But it is only by an exhaustive study of the osteological characters that any light can be brought here.

January 15, 1892.

IV. The Species of the Genus Pseudemys.

The genus *Pseudemys* was established by Gray * in 1855. The species referred to it were *Testudo concinna* LeC., *Emys hieroglyphica* Holbr. (*Pseudemys (?) hieroglyphica* Gray) and *Testudo rubiventris* LeC. (*Pseudemys serrata* Gray). Two years later, Agassiz † gave the generic name *Ptychemys* to the same group, distinguishing the following species:

Ptychemys rugosa Ag. (*Testudo rubiventris* LeC.).
" *concinna* Ag.
" *mobiliensis* Ag.
" *hieroglyphica* Ag.
" *decussata* Ag.

It is evident that *Ptychemys* Ag. is a synonym of *Pseudemys* Gray. As the type of this genus I consider *Testudo concinna* LeC.

* Gray, J. E., *Catal. Shield Rept. Coll. Brit. Mus.*, Part i, "Testudinata," London, 1855.
† Agassiz, Louis, *Contrib. Nat Hist. Un. States*, Vol. i, Boston, 1857.

Pseudemys concinna LeC., Gray.

This species was described by LeConte* under the name of *Testudo concinna* LeC. LeConte says: "Inhabits the rivers of Georgia and Carolina, where the beds are rocky. I have never seen them below Augusta on the Savannah, or Columbia on the Congaree." We have therefore to consider specimens from these localities as typical.

The upper jaw in this species is smooth, not notched, and without lateral cusps; the lower jaw is serrated and has a sharp median cusp on the symphysis. This species is characterized by its broad and low shell and its small head.

Pseudemys hieroglyphica Holbrook.

This species was described by Holbrook, in 1836, in the first edition of his *Herpetology* (Vol. i, p. 47, Pl. ii). The type now in the collection of the Philadelphia Academy came from the Cumberland river, Tenn.

A species very close to *Pseudemys concinna* LeConte, but distinguished by its elongated, narrow shell and its head, which is still smaller. The yellow stripes and dots on the head and neck are also very much more expressed than in *Pseudemys concinna* LeConte.

Pseudemys labyrinthica Lesueur, MSS., C. Duméril.

Boulenger places this species as a synonym of *Malaclemys geographica*, but there cannot be any doubt that it belongs to *Pseudemys*. It was originally described by C. Duméril, in *Catalogue méthodique de la Collection des Reptiles*, Paris, 1851, p. 13. The type specimens collected by Lesueur came from the Wabash river, Ill., probably from New Harmony.

That it cannot be *Malaclemys geographica* is at once seen from the description of the jaws: "Mâchoire inférieure dentelée, munie ásón extrémité antérieure d'un crochet venant se loger dans une petite échancrure de la supérieure." Duméril correctly compares it with *P. hieroglyphica* Holbr., and says: "Cette E. diffère de la précédente [hieroglyphica] par la forme de sa carapace, dont l'ovale est moins allongé, et par l'élévation quelle présente sur la ligne vertébrale, qui est au contraire déprimée dans l'E. hiéroglyphique, et enfin par le volume preportionellement plus considérable de la tête."

This species shows the coloration of head and neck of *P. hieroglyphica*, but the head is larger and the shell more as in *P. mobiliensis*, but by far not so large.

I have examined two heads of this form, from Illinois, preserved in alcohol; it is mentioned as *Pseudemys concinna* LeC. by H. Garman in "Notes on Illinois Reptiles and Amphibians" (*Illinois State Laboratory of Nat. Hist.*, pp. 185, 186). This species is said to be found at Mt. Carmel, Ill.

*LeConte, J., "Description of the Species of North American Tortoises," *Ann. Lyc. Nat. Hist.*, New York, Vol. iii, Febr., 1830.

Pseudemys floridana LeC.

In 1830, LeConte described a tortoise from the St. John's river, in East Florida, under the name of *Testudo floridana*. This species was recognized as distinct by Holbrook, in 1842, and figured (Pl. viii). Agassiz stated that it has to be considered a synonym of *P. concinna* LeC., and it seems that all recent authors have followed him.

There is no doubt that this species is distinct from *Pseudemys concinna* LeC. and *P. mobiliensis* Holbr.

The description given by LeConte is very good. The species is at once distinguished by its oval form and the great elevation of the carapace and its color. The carapace is not emarginate in front. It has a very dark-brown color, with numerous irregular lines of yellow. The marginals are also dark brown and have only one vertical median yellow line and are without the yellow concentric lines so characteristic for *P. concinna* and *P. mobiliensis*. The carapace is much more arched than in *P. mobiliensis* and nearly forms a half circle. The skull is also larger than in this species and the jaws are not serrated. This species seems to be restricted to Florida and Southern Georgia.

Pseudemys texana, sp. nov.

Agassiz mentions specimens of his *Ptychemys mobiliensis* "from Guadalupe mountains, Pecos river, Texas, and New Leon, near Cadereita, Mexico," and also young specimens collected in Texas by Mr. G. Stolley.

I have examined different specimens of this so-called *Ptychemys mobiliensis*, from Texas, and reach the conclusion that it belongs to a new species of Pseudemys related to *P. rubiventris* LeC., which may be called *Pseudemys texana*. As typical specimen of this new species I consider a stuffed specimen, No. 246, of the Philadelphia Academy, collected by Dr. Hermann in San Antonio, Texas.

Pseudemys texana, sp. nov.

Shell very thin behind, posterior border serrated, longitudinally rugose; nuchal long and slender; upper shell brown, with yellow reticulations similar to *Pseudemys concinna;* shell not much elevated. Plastron emarginated behind, yellow or with brown markings.

Skull small, similar to *P. rubiventris;* upper jaw notched in the centre, with a rounded tooth on each side, not so prominent as in *P. rubiventris*. Lower jaw similar to *P. rubiventris*. The coloration of the head quite different from the other species. A yellow longitudinal spot behind the eye; above this, a yellow line ending in a long longitudinal spot above the temples; from the lower posterior portion of the eye a yellow line appears, sending a branch upwards in front of tympanic cavity, and continues behind on the neck. Three very strong yellow and some slender yellow stripes on lower face of neck.

Locality of type, San Antonio, Texas.

There is a shell of the same species in the Philadelphia Academy. No. 247. It has the Smithsonian Institution number 7173 and was collected near Old Fort Cobb, I. T. The soft parts, limbs and head are preserved in alcohol at the Smithsonian. The two specimens mentioned by Agassiz are also at the Smithsonian (No. 80, Guadalupe mountains, Pecos river, Texas, and No. 76, New Leon, near Cadereita, Mexico) and belong to this species.

I consider *Pseudemys texana* as the representative of Pseudemys in the southern portions of this country west of the Mississippi—Texas, Indian Territory, Northern Mexico.

Pseudemys rubiventris LeC., Baur.

This species has been first mentioned by Say,* who described it erroneously as *Emys serrata* Daudin, in 1825. LeConte † introduced it as a new species under the name of *Testudo rubiventris* LeC., the "red-bellied terrapin, vulg." According to LeConte, it inhabits "in rivers from New Jersey to Virginia, chiefly in such as are rocky." He says that they are very numerous in the Delaware, near Trenton; specimens from this locality may be considered as typical, therefore.

In this form both jaws, especially the lower one, are strongly serrated; the upper one is notched mesially and has a cusp on each side; the lower jaw has a strong, median, serrated cusp and a notch on each side of it.

Pseudemys alabamensis, sp. nov.

In the collection of Mr. Gustave Kohn, of New Orleans, La., I found two specimens from Mobile, Ala., which are closely allied to *P. rubiventris*. They are at once distinguished, however, by their much more arched shell. This species has been noted by Agassiz as *Ptychemys mobiliensis*. It is, however, totally different from this, having the structure of the skull of *Pseudemys rubiventris* LeC. The shell is much more arched than in *P. rubiventris;* the coloration is like that in the latter form, but the plastron is yellow, or yellow with brown reticulations or dots.

Locality of types, Mobile bay, Ala. Collection of Mr. G. Kohn, New Orleans, La. This species exists in different museums, with the name *P. mobiliensis* Holbr.

Pseudemys mobiliensis Holbr.

The types of this species are from Alabama and are Nos. 241 and 242 of the Philadelphia Academy collection. I have examined the types and found that they are very close to *P. concinna* LeC. The skull agrees exactly with that of *P. concinna*, but is considerably larger. There is no notch in the upper jaw and no lateral cusps; the lower jaw only has a

*Say, Thomas, "On the Fresh-water and Land Tortoises of the United States," *Journ. Acad. Nat. Sc.*, Philad., Vol. iv, Part 2, 1825.

† LeConte, J., *l. c.*

sharp median hook, but no lateral notches. The upper jaw is very finely, the lower one strongly, serrated. A number of specimens in Mr. Kohn's collection from Mobile bay, Ala., and New Orleans, La., agree with the type.

Skull like *Pseudemys concinna* LeC., but larger; shell very much more arched, especially in front, than that of *P. concinna;* coloration as in the latter form. Animal much larger than *P. concinna*, the upper shell reaching a length of 385 mm. (over curve).

We have, therefore, the following species of *Pseudemys:*

Pseudemys concinna LeC.
" *hieroglyphica* Holbr.
" *labyrinthica* C. Dum.
" *floridana* LeC.
" *mobiliensis* Holbr.
" *rubiventris* LeC.
" *alabamensis* Baur.
" *texana* Baur.

These forms can be arranged in two series.

A. Both jaws strongly and coarsely serrated; upper one notched mesially, with a cusp on each side. Lower jaw with a median cusp.

1. *Pseudemys rubiventris* LeC., Baur.
   Type from Delaware, near Trenton.
2. *Pseudemys alabamensis* Baur.
   Syn., *Ptychemys mobiliensis* Ag. (part).
   Type from Mobile bay, Ala. In the collection of Mr. G. Kohn, New Orleans, La.
3. *Pseudemys texana* Baur.
   Syn., *Ptychemys mobiliensis* Ag. (part).
   Type from San Antonio, Texas. No. 246 Philadelphia Academy.

B. Generally lower jaw only strongly and coarsely serrated; upper without median notch, no cusps on the sides. Lower jaw with a median cusp.

1. *Pseudemys concinna* LeC., Gray.
   Type from upper parts of rivers of South Carolina and Northern Georgia.
2. *Pseudemys mobiliensis* Holbr., Baur (non Ag., non Boul.).
   Type from Mobile, Ala. Philadelphia Academy, Nos. 241, 242.
   Syn., *Emys orthonix* Wied.
3. *Pseudemys floridana* LeC., Baur.
   Type from St. John's river, Eastern Fla.
4. *Pseudemys hieroglyphica* Holbr., Gray.
   Type from Cumberland river, Tenn. No. 217, Philadelphia Academy.
5. *Pseudemys labyrinthica* (Les. MSS.) C. Dum., Gray.
   Type from Wabash river, Ill. Museum Natural History, Paris.

Stated Meeting, May 5, 1893.

Vice-President, Dr. RUSCHENBERGER, in the Chair.

Correspondence was submitted as follows:

Letters of envoy were received from the K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Bath and West and Southern Counties Society, Bath, Eng.; Royal Statistical Society, Meteorological Office, London, Eng.; Texas Academy of Science, Austin.

Letters of acknowledgment (139) were received from the Naturforschende Gesellschaft des Osterlandes, Altenberg, Germany; Deutsche Seewarte, Hamburg, Germany; Profs. Aristides Brezina, Matthew Much, Friederich Müller, Vienna, Austria; Société de l'Histoire de France, Paris; Sir John Evans Hensel, Hempstead, England; Philosophical and Literary Society, Leeds, England; Royal Astronomical Society, Victoria Institute, Royal Society, Royal Institution, Zoölogical Society, Institution of Civil Engineers, Royal Statistical Society, Royal Meteorological Society, Mr. C. Juhlin Dannfeld, London, England; Natural History Society, Newcastle-on-Tyne, England; Sir Lowthian Bell, Northallerton, England; Radcliffe Observatory, Prof. J. J. Sylvester, Oxford, England; Mr. Alfred R. Wallace, Parkstone, Dorset, England; Academy of Science, Rochester, N. Y.

Accessions to the Library were reported from the Zoologisch-Botanische Gesellschaft, K. K. Naturehistorische Hofmuseum, Vienna, Austria; Deutsche Seewarte, Hamburg, Germany; K. Sächs. Gesellschaft der Wissenschaften, Leipzig; Ministero di Agricoltura, Industria e Commercia, Rome, Italy; R. Osservatorio Astronomico, Turin, Italy; Royal Institution, Meteorological Council, Royal Microscopical Society, London, England; American Academy of Arts and Sciences, Cambridge, Mass.; Connecticut Academy of Arts and Sciences, Yale University, New Haven; American Museum of Natural History, Messrs. J. Wiley & Sons, New York, N. Y.; Smithsonian Institution, U. S. Department of Agriculture, Mr. J. C.

Mendenhall, Washington, D. C.; Prof. Alexander Macfarlane, Austin, Tex.; University of Michigan, Ann Arbor; University of Nebraska, Lincoln; Agricultural Experiment Stations, Amherst, Cambridge, Mass.; New Haven, Conn.; Newark, N. J.; Morgantown, W. Va.; Byran, Tex.; Lafayette, Ind.; Lincoln, Neb.

Mr. Fraley moved that the letter in reference to the Haldeman Indian collection be referred to the Curators, to report to the Society. Remarks were made by Dr. Morris, Mr. Prime and Prof. Cope. The Chairman observed that no objects should be loaned, according to a By-Law of the Society, except for the purpose of study. The motion was carried.

A portrait of the late Matthew Carey was presented to the Society, on behalf of the Hon. Henry Carey Baird.

On motion of Curator Dr. Morris, the Secretaries were requested to return to Mr. Henry C. Baird the thanks of the Society for the gift of the portrait of Matthew Carey.

Prof. Cope presented a paper for the Proceedings, by title, "Notes on the Classification and Taxonomy of the Testudinata," by G. Baur, University of Chicago.

Pending nominations for membership, Nos. 1249, 1250, 1253, 1254, 1255, 1256, 1257, were read.

Dr. J. Cheston Morris presented a communication from the Curators, which was received and referred to the Hall Committee for reply.

Dr. Morris moved that the Curators be authorized to dispose of such objects as are of no value to the Society.

Discussion by Dr. Brinton, Prof. Cope, Mr. Fraley, Mr. Prime, Dr. Morris. The motion was adopted.

Prof. Cope requested information about the programme of the Sesqui-Centennial Celebration.

Dr. Brinton gave information as to the action of the Committee appointed for the purpcse.

Remarks were made by Prof. Cope, Dr. Brinton, Dr. Morris, Mr. Fraley on the publication in reference to the proceedings of the Society in the public papers, with reference to the report of the proceedings of the Society at a previous meeting.

And the meeting was adjourned by the presiding member.

Stated Meeting, May 19, 1893.

The President, Mr. FRALEY, in the Chair.

In the absence of all the Secretaries at the opening of the meeting, Mr. Lyman was appointed Secretary *pro tem.*

Mr. Cramp, a newly elected member, was presented to the President, and took his seat.

Letters of envoy were received from the Royal Geographical Society of Australasia (Victoria Branch), Melbourne; Geological Survey of India, Calcutta; Université Royale, Lund, Sweden; K. K. Astronomisch-Meteorologische Observatorium, Triest, Austria; Musée Guimet, Bureau des Longitudes, Paris, France.

Accessions to the Library were reported from the Royal Geographical Society of Australasia (Victoria Branch), Melbourne; Finska Litteratur, Salskapet, Helsingfors; Lund University, Lund, Sweden; M. W. Pleyte, Leiden, Holland; Observatorio Marittimo, Trieste, Austria; Naturwissenschaftliche Verein, Bremen, Germany; Naturforschende Gesellschaft, Zurich, Switzerland; Academie N. des Sciences, Bordeaux, France; Société N. des Sciences Naturelles et Mathematiques, Cherbourg; Société de Borda, Dax; Academie des Arts et Belles-Lettres, Dijon; Union Geographique du Nord de la France, Donai; Société des Sciences Naturelle et Archæologiques de la Creuse, Guéret; Société des Sciences Naturelles, La Rochelle; Comité de Rédaction des Annales de la Faculté des Sciences, Marseille; Musée Guimet, Museum d'Histoire Naturelles, Société Zoologique de France, Société D'Anthropologie, Bureau des Longitudes, Société N. des Antiquaires de France, Paris; Société des Antiquaires de la Morinie, Saint Omer; Société de Geographie, Toulouse, France; Société de Geographie, Lisbon, Portugal; Geological Society, Manchester, Eng.; Natural History Society, Montreal, Canada; Boston Public Library; Academy of Sciences, New York;

Mr. Burnet Landreth, Bristol, Pa.; Mr. William John Potts, Camden, N. J.; Franklin Reformatory Home for Inebriates, Prof. E. D. Cope, Messrs. Alexander E. Outerbridge, Joseph Wharton, Philadelphia; U. S. National Museum, Prof. Edward Goodfellow, Washington, D. C.; Agricultural Experiment Stations, Geneva, N. Y.; Raleigh, N. C.; Lake City, Fla.; Brookings, S. Dak.

The donations to the library were announced.

The minutes of the Council meeting of the 12th of May were read. The resolution

> That the Council recommend to the Society the appointment of Messrs. Meehan, Houston and Price as a Committee to Examine the Catalogue of the Martindale Library, in order to ascertain if any books contained therein are important to complete our list, and if so, to purchase the same at a cost not exceeding $100—provided the money can be obtained from the income of the Michaux Fund, or by subscription.

recommended by the Council was considered.

Mr. Prime moved that Dr. Rothrock be added to the Committee. Carried.

Mr. Prime moved to amend by striking out from the last clause the words, "or by subscription." Carried.

The resolution so amended was carried.

The business of the election of new members was taken up.

Nominations Nos. 1250, 1253, 1254, 1255, 1256, 1257, 1258 and 1259 were read, spoken to, and balloted for.

Prof. Barker and Mr. Price were appointed tellers by the President.

Prof. Cope made a communication in regard to some stone implements occurring in Maryland, on the Potomac, the simplest yet found by him in forty years' collecting. The locality is two or three miles from the Potomac, is one-half mile to one mile in length, in material that is supposed to be derived from the Triassic and that has apparently been carried by floating ice. The locality is traversed by a small stream, with small hills on each side. There is a bed of reddish clay, up to six feet in thickness, filled with cobble-stones, many of them broken, and many worked; and some of them

have the external portions of the original shape entirely removed. Some of the most numerous class of them were exhibited, and have a portion of the original surface; others have a small portion of it; and others none at all. Many hundreds have been carried away by inhabitants of Washington, and many by Mr. W. H. Holmes, of the Bureau of Ethnology there. The method of manufacture was described; showing that the fractures could not be natural, but must be artificial. The question is, What are these objects? In Europe similar objects are reckoned as made by the earliest men, and are found at the lowest bed of the cave deposits. They are not polished. Now in Switzerland, for example, the paleolithic man is quite definitely associated with certain extinct animals. The later paleolithic man was an artist, while the following neolithic men were less artistic. Now, however, the Washington men insist that these ruder implements are only the imperfect or rejected implements of later men, merely the residue and rejected work of neolithic men; and in part the effect of weathering. One reason given why the more perfect implements are not found with them is, that the better ones have been carried away. The evidence in America is less perfect than in Europe, yet it is against supposing that the makers of the imperfect implements also had better ones. None of the better ones have been found in the whole region. The geological part of the investigation by the Washington men has been well done. At Trenton, however, they are thoroughly opposed by the good authority of Prof. F. W. Putnam. The history of man in America may be affected by the result of the discussion; but not that of European man. In America, too, the study of the caves has not been studied so far as in Europe; and the cave deposits give much the most trustworthy evidence. Mr. Clarence B. Moore has made important discoveries in Florida. He found a ramus of the lower jaw of a dog in a shell heap there this past winter. The shell heaps are post-Columbian. But this dog does not appear to be the present domestic dog. The jaw has three premolar teeth, instead of four, a deficiency which is

rare in the recent domesticated or wild dogs. There are also other peculiarities. Probably it is an extinct species, and it is a normal healthy specimen.

Prof. Ryder made a written communication for the Proceedings, entitled, "The Adaptive Forms and the Vortex Motion of the Substance of the Red Corpuscles of Vertebrates." He gave orally the substance of the paper.

The tellers reported the following named to have been duly elected members of the Society:

2218. Hon. Charles P. Daly, New York, N. Y.
2219. Prof. Isaac H. Hall, New York, N. Y.
2220. Gen. Isaac J. Wistar, Philadelphia.
2221. Mr. Edward Vincent d'Invilliers, Philadelphia.
2222. Prof. Waterman L. Hewitt, Ithaca, N. Y.
2223. Dr. Justin Winsor, Cambridge, Mass.
2224. Dr. William Hyde Appleton, Swarthmore, Pa.
2225. Prof. James E. Rhoads, Bryn Mawr, Pa.

Mr. Blodget obtained unanimous leave to make a communication. He had prepared a series of ten maps to show the resources of the State of Pennsylvania for the Chicago World's Fair. The maps are some thirty inches by twenty inches. Bituminous coal, oil and other products are represented on the series of maps, showing their past and present importance. The true capitalization of the yearly industrial earnings of the State he finds to be about $10,000,000,000. The results have been reached by five or six months' labor.

And the Society was adjourned by the President.